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CONTENTS

Control of Health Hazards in the Operation of Metal Degreasers

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BECAUSE trichlorethylene is commonly recommended as a substitute for carbon tetrachloride, possibly we get the feeling that trichlorethylene is not a hazardous substance. Despite this feeling, however, sometimes we are reminded that trichlorethylene is quite hazardous when we encounter a serious poisoning episode. Within the last two years, two such serious episodes were experienced in Massachusetts. In addition, Spolyar and his associates in Indiana have reported the fatal poisoning of a worker either by trichlorethylene or by phosgene formed by the decomposition of trichlorethylene.

During the last war, industrial hygienists found that they frequently encountered unusual problems which had to be solved by what had been regarded as unconventional methods. This again may be true during the present defense effort. It is also true that because of the speed-up in production to meet military requirements, degreasing equipment may be often overloaded, with the result that machines which previously have been operated without ventilating equipment must be ventilated in order to control the worker's exposure to trichlorethylene. It is also apparent that equipment designed for a certain use may be put to use for purposes for which it

was not intended. Such cases are bound to occur where manufacturers may be hard put to obtain degreasing equipment and may buy either second-rate equipment or may even possibly build their own equipment. These practices can easily lead to trouble.

In considering this problem, then, it is necessary that we define the areas of interest. In the first place, we must consider acute hazards, in which workers are exposed to exceedingly high concentration of the vapor of the solvent being used. As previously pointed out, this can occur where home-made degreasing equipment is utilized or where manufacturers may use improperly designed degreasers. Another place where acute hazards can occur is during the cleaning out of degreasing tanks. The second field of interest lies in the chronic exposures to the vapors of the degreasing solvents. Hazards may occur from the improper use of properly designed degreasers, from the introduction of unusual types of articles to the degreaser, from the overloading of degreasers and from increased production demands.

A number of years ago in Massachusetts the folly of using home-made degreasers which almost always are improperly designed was brought to the attention of authorities when an 18-year-old white male worker became seriously ill. Despite the common belief that trichlorethylene af-

fects only the central nervous system, this worker became seriously jaundiced as a result of his exposure to the high concentrations of trichlorethylene which escaped from the home-made degreaser. In this particular instance little attention was paid to the proper design of the degreaser inasmuch as there were no cooling coils located about the periphery at the top of the degreasing tank. In addition, there were no thermostatic controls to regulate the heat input into the degreaser and inasmuch as there were no cooling coils, there properly could be no freeboard to help in keeping the vapors below the top level of the degreaser. Despite the fact that this worker was exposed to trichlorethylene vapors for a total of only 54 hours during the month he worked with it, he became seriously jaundiced as a result of his exposure.

Spolyar[1] has reported a fatality as a result of a worker's exposure to either trichlorethylene or phosgene during the operation of a degreaser, which had been purchased second hand and had been originally designed for use with perchlorethylene. Studies made after the poisoning episode indicated that the worker probably had been exposed to concentrations of trichlorethylene in excess of 10,000 parts per million. These high concentrations resulted because the controls had been set for perchlorethylene.

TWO CASES of acute poisoning by trichlorethylene have been experienced recently in Massachusetts when workers were engaged in cleaning out degreasers. In the first instance, reported by Maloof[2], the worker entered the degreaser and was overcome by the vapors. In addition, he suffered severe skin burns, but recovered. In the second instance[3] the worker cleaned the degreaser while standing in a pit located adjacent to it. He was overcome by the vapors and died in the pit. Tests made subsequently indicated that he probably had been exposed to concentrations of approximately 18,000 parts per million.

These episodes illustrate the folly of using improperly designed degreasers, and of using degreasers for purposes for which they were not intended. They also show that workers should be protected during clean-out operations either by adequate ventilation or by supplied air respiratory protective equipment. They indicate also that some type of impermeable clothing should be used to avoid skin burns during clean-out operations.

While the foregoing episodes are rather unusual, they do serve to bring our attention to the hazards encountered in the use of trichlorethylene in degreasing equipment. However, despite the dramatic effect that such episodes might have upon us, we should not lose sight of the fact that workers are chronically exposed to hazards from the use of this type of equipment. Such hazards can occur from the improper use of properly designed degreasers, from unusual types of work, from overloading of the degreasers or from the demands of increased production. Vapors of trichlorethylene can escape either from the degreaser or from liquid adhering to parts after they have been removed from the degreaser.

There are several reasons for the escape of vapor from the tank. If work is put into the tank in large baskets which almost fill the cross-sectional area of the tank, a piston-like effect is created and visible vapors often escape. In other cases, excessively heavy material is introduced, producing an almost instantaneous condensation of the vapor and inducing a flow of air into the partially evacuated tank. The air thus introduced eddies about the tank and becomes intimately mixed with any vapors remaining. When the vapor level is again raised the trichlorethylene-laden air is displaced and contamination of the work area ensues. An additional factor may be involved where degreasers are overloaded. When heavy large parts are introduced into the boiling liquid into the bottom of the tank cooling occurs. This results in the control valves increasing the heat input. When work is removed from the liquid the high rate of heat input continues for a short time and vapor is generated rapidly at the time when the heavy hot work is passing through the condensing zone. Inasmuch as the work is at practically the temperature of the trichlorethylene, condensation does not take place on the work. Thus,

some of the vapor can escape from the tank during this period.

Too rapid introduction of work to the degreaser may also produce such air disturbances that result in the eddying of the air and vapors and cause vapor to be lost from the device. Vapor also will escape from a degreaser if it is located in such a place that high velocity drafts from unit heaters, ventilators, open doors or windows pass over the equipment. In one plant we found concentrations of 170 to 230 parts per million of trichlorethylene because of high drafts from windows adjacent to the degreaser, whereas we found concentrations of 30 to 40 parts per million when these drafts were eliminated by means of baffles. Thus, it is apparent that in the installation of degreasers or of supply air equipment, care must be exercised that high room air velocities are not maintained in the vicinity of degreasers.

Where parts having recesses are degreased, vapors may also escape to the working atmosphere. This is particularly true if large numbers of cup-shaped objects are introduced to a degreaser. Hot liquid condensing on the metal is collected in the recesses, is later carried out and readily evaporates into the room because of the fact that it is at a high temperature. This phenomenon is usually referred to as "drag-out."

The question arises, how often do we encounter these hazards and how may we correct them? Many times we have been confronted with the statement that ventilation is not necessary if a degreaser is properly operated. Ordinarily properly designed degreasers, if properly located and properly operated, do not require exhaust ventilation. It has been our experience that in at least three-quarters of the degreasing operations we have seen, the degreasers should not require ventilation control. Unfortunately, some of these were not properly operated or properly located, and, therefore, ventilation was deemed necessary for them. Morse and Goldberg[4] have studied concentrations of trichlorethylene in the vicinity of non-ventilated tanks. They found that 79.9% of the samples taken showed concentrations of 200 parts per million or less.

Fig. I.
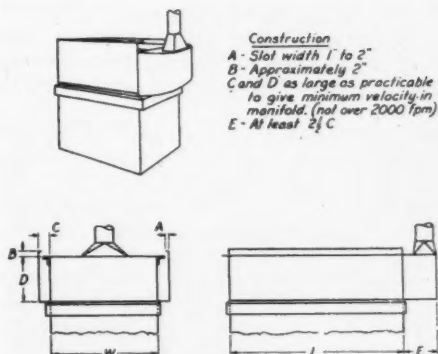
Slot and manifold design. Harris, Ford, Patty and Hatch report $Q = 120 (L + W)$; Brandt gives $Q = 50LW$; Witheridge and Walworth state $Q = 30LW$. Manifold and pipe velocities are not to exceed 2000 fpm.

CERTAIN control measures have been incorporated by the manufacturer in order to prevent as much as possible the escape of trichlorethylene vapor to the working atmosphere. These measures include the provision of cooling coils which are located about the sides of the tank. Their purpose is to condense the vapor to prevent it from rising above a pre-determined level. In addition, thermostatic controls are placed in many instances above the cooling coils, so regulated that the heat input is reduced or stopped when the vapor level rises too high. The space above the cooling coils is called the freeboard and increasing this height adds a factor of safety. This height should never be less than one-half the tank width.

Probably the most widely accepted method is the provision of lateral exhaust slots on either of the two long sides of the degreaser. Harris et al[5] recommend providing an exhaust rate of 60 cubic feet per minute per linear foot of tank perimeter. On the other hand, Brandt[6] recommends 50 cubic feet per minute per square foot of tank area while Morse and Goldberg[4] recommend 30 to 40 cubic feet per minute per square foot and Witheridge and Walworth[7] found that 30 cubic feet per square foot of tank area resulted in adequate control. It is usually thought that this method

of control is local exhaust but a study of the situation reveals that local exhaust and dilution of vapor occur. Hemeon[8] has ascribed most of the control action to dilution.

If we considered a typical degreaser tank four feet long and three feet wide, we should have exhaust rates of 840 fpm according to Harris, 600 fpm according to Brandt and 360 according to the other authorities. In considering the first requirement of 840 cubic feet a minute, we find that 420 cubic feet a minute would be exhausted through each of the slots. In order to simplify the discussion, let us assume that the slot is a line source of suction in space and the velocity contours are cylinders of revolution. Since the volume of air moving is the product of the velocity and the area, we find that 420 cubic feet is equal to AV. Since room currents do not usually exceed 50 feet per minute we shall take this value as being sufficiently great to induce vapors into the exhaust opening. Therefore, 420 is equal to 50A or the area A is equal to 8.4 square feet. Since the area of a cylinder of revolution is equal to $2\pi rl$ we can calculate that the effective radius is only .33 feet or four inches. Since the degreaser in question is three feet wide, it is apparent that the control of vapor cannot be due entirely to local exhaust. Where the lower air flows are used, the controlling distance is less than four inches. While this consideration of the mechanism of slot ventilation is over-simplified, it is apparent that controlling velocities exist only a short distance from the slot. Therefore, Hemeon's theory that dilution is the important mechanism involved is apparently correct.

While the foregoing ventilation method is entirely adequate and is desirable in many cases, at times, difficulty in securing sheet metal has demanded substitute methods. One such successful plan seen by us involves installation of a propeller fan in the wall directly behind the degreaser. This may seem to contradict our previous statement regarding the avoidance of drafts but the following explanation should dispel this idea.

If we consider the propeller fan to be

$$Q = V(10x^2 + A)$$
$$= 75(10h^2 + LW)$$
where h = height of basket
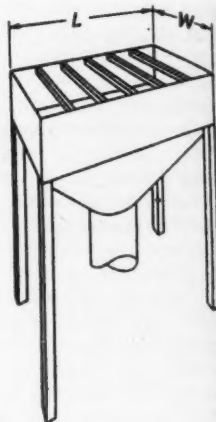
Fig. 2.
Sketch of downdraft ventilated grill for the removal of trichlorethylene vapors dragged out by recessed articles.

a simple round opening under suction, we find that the velocity contours at the inlet side drop off rapidly as the distance from the fan is increased. Since the average propeller fan creates an average velocity through its cross section of approximately 1500 fpm, we find that at 1.5 diameters the 3% velocity, namely 50 feet per minute, is reached. On the other hand, if the same propeller fan were turned about and forced air over the degreaser, it would create a velocity of 50 feet per minute at about 80 diameters distance. Thus, while such a fan can be used to exhaust the vicinity of a degreaser without creating undue drafts, the same fan, if used for circulating purposes, would be undesirable unless removed more than 80 diameters from the degreaser.

A MODIFICATION of the propeller fan method was encountered in another plant. This involved the location of the degreaser in a large booth. Velocities of approximately 30 feet per minute existed at the working edge. Concentrations of six parts per million were found to exist at this location. A propeller fan was used to provide the air motion.

While these methods are all adequate in controlling the escape of trichlorethylene

Fig. 3.
Downdraft grill in work bench used in the jewelry trade for the removal of trichloro-thylene vapors carried out by chains. The plenum chamber located under the bench has been opened up to show the propeller fan.
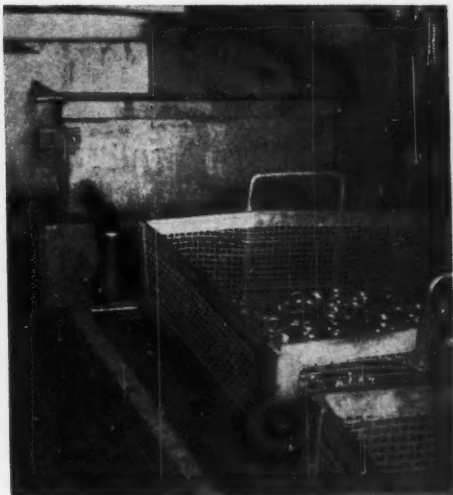
Fig. 4.
Degreaser ventilated by lateral slots and a downdraft grill located in an adjacent table for the removal of vapors caused by drag-out.

from the degreaser itself, they do little toward reducing concentrations occurring because of the drag-out of hot liquid. Drag-out can be partly minimized by proper design of baskets used to hold the work. If care is taken to eliminate recesses at the corners and to provide only wire baskets some drag-out will be eliminated. Additional drag-out loss can be reduced by holding the basket in the freeboard area of the degreaser for a short period of time after the material has been degreased. However, in some cases where production demands speedier operations this cannot be done. In other cases, because of the recessed character of the material being degreased, liquid drag-out is inevitable. In such cases, it is necessary to provide mechanical exhaust by means of a ventilated drain stand. The best method of accomplishing this is through the use of a grill-top, downdraft hood sufficiently large to accommodate the basket being used. The proper air flow can be calculated by using Dalla Valle's equation.[9]

It is not uncommon to find instances where control by this latter method alone

will reduce the exposure of the worker to the safe limit. We have found such instances in the jewelry trade where chain and small recessed articles are often degreased. The size and quantity of these are generally so small that no appreciable load is demanded of the degreaser, and thus, if proper operation is observed little escape of vapor occurs from the degreaser itself. However, air contamination from the liquid carried out by the degreased articles is quite likely to be high. One jewelry shop found an effective method of controlling the vapors in such a case was through the provision of a grill in a work bench which was completely covered in at the bottom and the plenum chamber thus formed was exhausted by a propeller fan. We found a velocity of 550 feet per minute eight inches above the grill which was five feet removed from the degreaser. Concentrations of trichlorethylene were well below the allowable limit.

In another plant where metal bus seats were being degreased a similar ventilation arrangement was in effect. A vapor phase degreaser approximately seven feet by 30 inches was located next to a stand formed

Fig. 5.
Utilization of the covers of a degreaser with
an additional plate to prevent drafts from af-
fecting the operation of the degreaser.

of two "I" beams joined by metal rungs. A propeller fan with a capacity of 4500 cubic feet per minute was located 18 inches from the drain stand at floor level. The highest concentration found in this instance was 10 parts per million while on three of four samples the analytical method was not sensitive enough to detect any trichlorethylene.

In some cases contamination of air occurs from both the material dragged out and from the degreaser itself. In such instances it has been found necessary to exhaust both the degreaser and the drain stand. In many cases it has been found possible to place the stand immediately adjacent to the degreaser and connect it directly to the plenum of the tank exhaust system.

IN SUMMARY, acute poisoning episodes can occur through improper use of degreasing equipment. They can also occur during clean-out operations if the workers are not properly protected with personal respiratory protective devices and particularly if workers enter enclosed spaces alone, or not under the supervision of a co-worker. Chronic exposure to trichlorethylene vapors can occur during the improper operation of properly designed degreasing equipment.

In some cases such improper operations are brought about because of production demands. In other cases it occurs primarily through ignorance.

Despite these exposures it is possible to control either the acute or chronic exposure. It is extremely important that only properly designed degreasers be operated. Furthermore, it is of great importance that no worker be allowed to enter a degreaser or a pit located adjacent to a degreaser unless he is provided with proper respiratory protection and, further that his work is being supervised by another worker, who will be able to notify others in order to rescue the first worker in the event any mishap occurs. The experience reported here, by Spolyar, Maloof and in England indicate that workers who are exposed to high concentrations of trichlorethylene vapors should have protective equipment to prevent burning of the skin in addition to the personal respiratory protection.

Various methods of providing control measures to eliminate chronic exposures have been described. These include the utilization of cooling coils and thermostats provided by the manufacturer and the provision of ventilation to control the escape of trichlorethylene from the tanks and also to control the escape of trichlorethylene vapor from the hot liquid often dragged out of the degreasers by the material being degreased.

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The Noise Problem in Industry

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THE GROWING interest in industrial noise among representatives of industry, and the medical, industrial hygiene and other professions is not an accident. The fact is that excessive noise exposures in industry have caused loss of hearing among certain workers and this has created many problems. While these facts are well known, the interest shown in industrial noise by industry and the professions has not been great enough in the past to stimulate the necessary research for solving the problems created. Now we may be faced with a certain amount of urgency for solving the problems which were created over a long period of time.

As a result, those who are responsible for worker protection against the effects of noise are becoming increasingly concerned as to what steps to take. Not long ago, I was discussing the noise problem with a fellow industrial hygienist and he summarized his views at that time by saying, "I know of no other industrial hygiene problem which has left me with such a helpless feeling. It is usually possible to apply basic industrial hygiene principles and come up with the answers. However, with noise it is different."

On the surface, one might say all that is necessary is for the workers to wear ear "plugs" or that the plant install acoustical materials to accomplish adequate control. However, the problem is much more complicated and the need for additional research in this field is gradually being recognized. A comprehensive survey will convince most people that the problem is complex and that the potentialities are great.

Therefore, expressions of uncertainty are natural and justified at this time. Speaking for the industrial hygienists, it is believed that in general they are not yet adequately familiar with the basic principles of the problem. Needless to say, they are not alone for the other professions

concerned by no means have all of the answers. However, if the industrial hygienist is to assume his proper roll in this field it will be necessary for him to prepare by providing himself with a liberal education. Certainly we must learn more about the physics of noise and noise control before we can apply basic industrial hygiene principles and become of maximum service to industry. We cannot become experts by proclamation.

In some respects it is strange that industrial noise should assume the importance it has at this particular time, for deafness and loss of hearing have been associated with excessive noises for well over a hundred years. However, as one reviews our present knowledge he certainly will conclude that we are not completely prepared. The fact that deafness or loss of hearing may be caused by other factors than exposure to excessive noises, complicates certain phases of the problem. Some of the other questionable factors in the over-all noise problem are related to:

1. Permissible noise intensity levels as related to the frequency spectrum.

2. Standard techniques for measuring noise intensity and frequency. This is concerned with:
   a. Acceptable instruments
   b. Methods of calibration of instruments
   c. Tape recording and methods for determining intermittent intensity levels

3. Engineering Control
   a. Substitution (questionable value)
   b. Engineering control at source
   c. Isolation (distance)
   d. Acoustic treatment
   e. Ear protectors

4. Medical factors
   a. Specifications for acceptable room for audiometric testing
   b. Standard procedures for audiometric testing
   c. Standards for calibration of audiometers

   d. Standards for interpretation of audiograms

   e. Clarification of factors to be considered for determining industrial hearing loss

   f. Medical control programs in noisy trades

   g. Testing procedures for determining noise "susceptibility"

5. Problems relating to loss of hearing and compensation.

The Noise Problem

NUMEROUS studies have been conducted in certain industries to show that loss of hearing was a common occurrence. Unfortunately, however, too little has yet been learned about temporary versus permanent effects, effects of age, and the different types of deafness. Above all, there has been very little correlation between loss of hearing and exposure to different noise frequencies and intensities in various industrial operations.

Although loss of hearing may be directly related to excessive noise exposure in certain industrial operations, can we refer to excessive noise as a *health* hazard? On the surface, it would seem that we cannot because in industrial loss of hearing there is no direct damage to health. Perhaps there are many people who would disagree on this point on the basis that it is an attempt at making too fine a distinction since industrial loss of hearing is the result of biological change over an extended exposure period. In other words, any injury affecting a biological process is directly related to health. If this is a logical assumption, it would appear that excessive industrial noise can be considered a health hazard. In any case, it is important to remember that noise exposures in industry vary from health hazards in these respects:

1. High level noise exposures may occur in the home due to traffic or other causes, and in other environments as well as in industry. Health hazards are usually associated with certain specific industrial processes or operations and similar exposures are not usually found elsewhere.

2. Loss of hearing is a natural progressive process, and increases in all people with age.

3. Loss of hearing may have no relation to exposure to noise, for it can be the direct result of certain common diseases.

4. Loss of hearing does not normally result in disability in the same sense that disability occurs in the case of an occupational disease. Loss of hearing usually does not interfere with job performance.

According to an accepted definition, "industrial hygiene is the science and art of preserving health through recognition, evaluation and control of environmental causes and sources of illness in industry." If we accept this definition as being correct, it must be agreed that the measurement and control of industrial noise is a proper function of industrial hygiene.

Permissible Noise Levels

BEFORE considering permissible industrial noise levels, perhaps it would be advisable to compare some common sounds and their energy equivalents with loudness measured in decibels. Fig. 1 shows decibel and equivalent energy for common sounds, and compares intensities of every-day noises. This gives a picture of over-all noise intensities and does not consider frequencies.

Individual susceptibility is a term common in the industrial hygiene field. We know, for example, that all workers exposed

Fig. 1.
Comparison of common sounds

to the same silica dust concentrations for similar periods of time will not develop silicosis. Now the otologists tell us that the individual susceptibility factor may have much greater significance in industrial noise exposures than in industrial health exposures. Before accepting this theory without qualification, it is believed that studies of noisy environments and actual exposures should first be correlated with loss of hearing. The fact that day to day exposures of workers on the same jobs can vary greatly because of differences in individual protection, movement about the plant, and other factors tend to throw some doubt on the soundness of the susceptibility theory. However, if this theory proves to be sound, it will have considerable influence on the establishment of equitable permissible noise levels. Research work now is in progress to develop a test for determining noise susceptibility in unexposed persons.

At the present time, there is little reliable scientific data on which to establish permissible noise levels. An over-all 90 decibel noise level has been suggested, but this does not take into consideration the possibility that noise in certain frequencies may be more harmful than in other frequencies. While it is now known that this is the case, there is evidence to indicate that noise in the middle frequencies may be more damaging than low frequency noises.

Therefore, we need better correlation between loss of hearing and exposures to noise intensity levels in the various frequency bands. The over-all intensity level as measured by the noise level meter does not give a satisfactory answer to noise levels in the various frequency bands. This is demonstrated in Fig. 5. Perhaps it is too much to expect permissible levels for each of the eight frequency bands (20-75; 75-150; 150-300;—4800-10,000) found on certain octave band analyzers. For this reason, it is suggested that three different permissible levels might be applicable in industrial noise control. Perhaps this could be done by roughly dividing the "0 to 10,000" cps frequency range into low, medium and high frequencies and applying a permissible noise intensity level in decibels to each group. It is hoped that present

research work being conducted by the Sub-Committee on Noise in Industry of the Committee on Conservation of Hearing of the American Academy of Ophthalmology and Otolaryngology will contribute data which will permit establishing threshold levels in certain specified frequency ranges.

Perhaps it is sufficient to say at this time that an over-all permissible noise level is not adequate and that we are in need of permissible noise levels for industrial exposures in at least three frequency ranges.

Noise Measurement

IT WOULD appear that the evaluation of industrial noise exposures involves the same basic principles of sampling which are commonly applied for determining exposures to toxic materials. In industrial sampling and analysis of toxic materials, an attempt is made to accurately evaluate worker exposures, to determine the source of the contaminant, and to collect data pertinent to control of the potential hazard. This is essentially what is being sought when evaluating industrial noise. However, it is possible that noise intensity levels may be more uniform in any industrial exposure from day to day than concentrations of toxic materials. Perhaps one of the most difficult problems in the interpretation of noise measurement data involves corrections of readings for background noise. This will be covered later.

Before proceeding further with the subject of noise measurement, I should like to mention briefly the importance of a scientific approach to sampling. Good sampling techniques are the most important part of hazard evaluation, and yet the most simple rules of sampling are too frequently violated. In general, it requires little knowledge to operate sampling equipment, but considerable training and experience is required for sampling to scientifically evaluate a hazard.

The sound or noise level meter is a device for measuring the amplitude of rapid alterations in air pressure. The noise level meter is intended to provide a simple means of obtaining measurements which can be correlated with the response of the average ear, although it is by no means perfect in this respect.
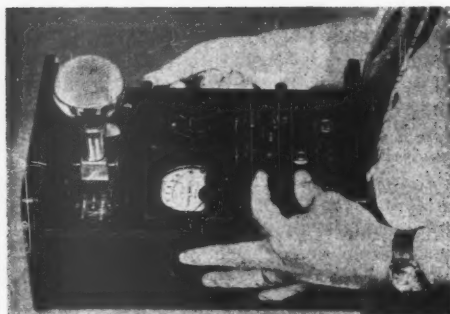
Fig. 2.
Sound level meter

Fig. 2 shows a sound level meter which is suitable for measuring over-all noise levels and can be applied to many noise problems, particularly where only relative noise levels are desired. For example, the instrument is valuable for determining "before" and "after" noise intensities where control has been installed. In fact, the instrument was originally designed for this purpose and some doubt may be expressed as to its value for determining absolute intensities.

Not enough is known about the human ear to duplicate response to sound in a single scientific instrument. The complicated characteristics of the ear are illustrated in Fig. 3 which shows the Fletcher-Munson curves of equal loudness. These equal loudness contours or curves represent the response of the average ear to pure tones in terms of frequency and loud-
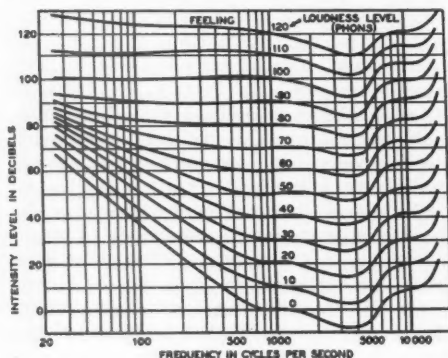
Fig. 3.

ness level. These indicate that the frequency response of the ear is not constant, but varies with the loudness of the sound. For example, at low sound levels the ear is relatively insensitive to low frequencies. At high sound levels the response of the ear is about the same for both low and high frequencies. This means that readings of intensity have to be converted in order to measure loudness.

This may also be a partial explanation for the statement previously made that noise in the middle frequencies may be more harmful than the same noise intensity levels in the low and high frequencies. Since the ear reacts more readily to noise in certain frequency bands, would it not seem logical that those same frequencies in high intensities might be more harmful?

The noise level meter measures results in decibels which are dimensionless units expressing the ratio of two values of power. A level of zero decibels roughly represents the weakest sound which can be heard by a person with excellent hearing. The zero decibel or reference level is a pressure of 0.0002 dynes per square cm. at 1000 cycles.

Since the decibel is a logarithmic function, decibel values cannot be added because such addition produces multiplication of sound pressures. Two sounds of equal power when added together produce twice the power which is equivalent to two sound pressure. For example, the noise from two similar machines will produce a total sound pressure of two times the sound pressure for one machine. A simple rule to remember is that when two sounds of equal intensity are brought together, the resulting noise level is three decibels higher.

In making industrial noise measurements in connection with any one machine or process, it may be necessary to apply a correction for the background noise. Ordinarily, measurements should be made when the background level is negligible. Since this is frequently impossible, certain corrections to the observed meter reading should be made. Published data is available in graph form for this purpose and will not be discussed at this time.

In order to get a complete picture of a sound or noise, it must be broken-down into its various frequency components. A

Fig. 4.
Octave band analyzer

Fig. 5.

frequency analysis of a noise source gives two general answers: (1) noise intensities in various frequency bands and (2) clues to the source of various noise components. This information will become invaluable in the application of control.

An octave band analyzer is shown in Fig. 4. The actual mechanics of operating this equipment are not complicated, but the important step in its use are concerned with proper application and noise measurement. The instrument is used in conjunction with the sound level meter as the noise pick-up device.

It is possible that in certain industrial applications, the noise level meter and octave band analyzer may have little, or at least limited application. When intermittent noises are encountered such as with punch press operations, the instruments will not respond rapidly enough to allow for collecting accurate data. In addition, the source of the noise may not last long enough to allow the instruments to respond and give maximum readings.

To handle this problem some investigators use the tape recorder and interpret the data in the laboratory at a later time under controlled conditions using the oscillograph.

This has been observed in actual practice with the following general results: A certain punch press operation was studied for both noise levels and frequency. In certain frequency bands, the maximum observed noise level was between 110 and 115 decibels. However, when this was recorded and later replayed using the oscillograph,
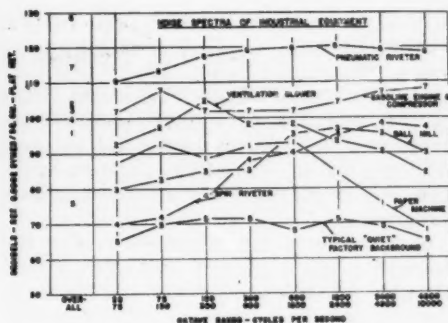
maximum intensities of 130 decibels were observed. At these intensities, assuming a continuous noise, pain and traumatic injury is usually experienced within a very short period of exposure.

The fact that such injury does not occur in connection with these operations suggests that the ear fails to react to these high noise intensities in perhaps the same manner as the noise level meter. And yet, a long period of exposure to these intermittent noises may cause loss of hearing. This is another phase of the noise problem which needs further study and further complicates the establishment of permissible noise levels.

Fig. 5 shows results of noise analyses for various types of machines. These data immediately suggest that by controlling high noise levels in certain specified frequencies, it may be possible to control many noise problems.

Noise Control

THE BASIC methods of noise control do not vary materially from the control of occupational disease exposures. However, the technical problems involved vary greatly. These usual control methods are:

1. Substitution. This would include substitution of products which are manufactured by quiet processes. This method has limited application.

2. Engineering control of noise at its source. It develops that this subject is the basis of a research project currently in progress at the Armour Research Foundation. When this study is completed, it is believed that considerable valuable data

will be available on industrial noise control.

3. Segregation or isolation of noisy processes. This would include use of acoustical materials for enclosure, improved plant layout, or isolation of the process so that large numbers of workers are not exposed. This method of control has greatest application during plant building and expansion programs.

4. The use of ear protectors. As in the case of respirators, ear protectors should be used where other control methods are not practical, or where further protection may be indicated. The applicability of ear protectors for individual protection is in a state of flux at the present time. The important factors to consider in the selection of any ear protector are: (a) Comfort; (b) Efficiency; (c) Cost. Thus far, these factors have not been generally evaluated for the ear protectors now on the market. However, this matter is being given attention by the Sub-committee on Noise in Industry of the Committee on Conservation of Hearing of the American Academy of Ophthalmology and Otolaryngology. It is hoped that this information may be made available within the reasonably near future.

In closing, a plea is made for industrial hygienists to become prepared in this comparatively new, or rather expanding field, where industrial noise problems will be encountered. An understanding of the basic principles involved is of immediate importance. Certainly a symposium on noise for the industrial hygienist is needed. This should not be a general noise symposium, but rather a technical program covering the fundamental principles of noise measurement and control.

In the meantime, certain "must" reading is suggested, including the now famous Kryter report which lists several hundred references.

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"The Acoustical Spectrum"

WILLIAM P. YANT was a member of the Planning Committee for the Inservice Training Course on "Sound—Wanted and Unwanted," at the University of Michigan School of Public Health, February 5-8; and it was he who suggested that the Course content be called "The Acoustical Spectrum." This is a good name. Color has its "v-i-b-g-y-o-r," and sound is entitled to its identifiable gamut. The Course was replete with identifications, each merging into the others. As "white light" embraces all light-wave lengths, and "white sound" has been used to emcompass all pertinent wave-frequencies, so the term "white discussional" might well be applied to the presentations at Ann Arbor. The four-day sessions, shared in by 250 participants, heard successively about the measurement of sound, the business of hearing, the control of noise, and the medicolegal implications of such things as standards and compensation for alleged injury from noise. Measurement dealt with instruments and techniques for physicians and hygienists; the business of hearing with the anatomy and physiology of "sound at work; ears receiving sound; the affronted ear cells"; and noise control—the province of the industrial hygienist—with the means of control on all levels from industrial and business buildings to communities; while the medicolegal day demonstrated that the noise deafness is a reality, and raised innumerable questions regarding its compensability. The School of Public Health is publishing the whole Course—24 Lectures—in BOOK form, available April 1. It may be procured through MR. H. E. MILLER, 109 South Observatory St., Ann Arbor, Michigan.

Determination of Gaseous Air Pollution by Carbon Adsorption

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A COMMON problem in air purification, whether for indoor comfort or outdoor nuisance abatement, is the determination of the prevailing concentration of air-entrained gaseous and vaporous contaminants. While determinators usually employing specific reactants for some one particular substance like, for example, sulphur dioxide, are available, these by virtue of their exclusive limitation for that substance are not suitable for general application. This limitation is overcome by the use of sorbents because of their more diversified properties of attraction. Of these, activated carbon, being least selective, has proved most adaptable.

Activated carbon will adsorb petroleum and hydrocarbon vapors, the odors from decomposition and putrefaction, and most of the air contaminating gases incidental to industrial and chemical processes. Moreover, the carbon's adsorptive capacity, efficiency and retentivity* for these widely varied substances is predictable[2,8] and further, the actual sorption is measurable since the sorbed substances can be reclaimed by the process of desorption or reactivation. Thus, activated carbon can be employed fairly indiscriminately to ascertain the prevailing concentration of one, several, or a conglomerate variety of air entrained gaseous impurities. Table I lists the properties of a gas adsorption carbon suitable for collection of atmospheric contaminants.

Previous workers[3,9] using activated carbon to determine gaseous atmospheric contaminants followed the procedure of drying the air to be analyzed and then measuring the weight increment added to a sample of activated carbon by a known volume of the dried, contaminated air. Two disadvan-

*Retentivity is the percent by weight of an adsorbed substance retained by the carbon on exposure to the ambient air. Activated carbon, while it retains adsorbed organic vapors, will lose its adsorbed moisture to a dry air stream, thus showing no retentivity for moisture.

TABLE I.
SPECIFICATIONS FOR GAS ADSORPTION CARBON

Property	Specifications
Retentivity for CCl₄, 20°C, 760 mm.	At least 30%
Apparent density	At least 0.42 g/ml.
Hardness (ball abrasion)*	At least 80
Mesh distribution	6-14 range (Tyler)

*Percent of 6-8 mesh carbon which remains on a 14 mesh screen after vibrating with 30 steel balls of 0.27-0.37 in. diam. per 50 g. carbon for 30 min.

tages of this method are evident and serious. First, in the ranges of low concentrations of contaminants, the adsorption of non-aqueous matter by the drying agent will be significant. Smyth[9] obtained such erratic results in using activated carbon to determine benzol vapor concentrations that he abandoned the method for his survey. Cook and Coleman[3] used the method satisfactorily for determining organic vapor concentrations in the ranges of 120 p.p.m. to 10,000 p.p.m., which are far above commonly encountered concentrations in urban industrial atmospheres. Second, the use of small samples of carbon and, therefore, relatively small volumes of air makes it impracticable to adsorb sufficiently large amounts of vapors for analysis of unknown contaminants. It is therefore important to use a scheme of analysis and a fairly compact apparatus which will yield qualitative and quantitative determinations of gaseous contaminants present in very low concentrations. In order to do this, there is required (1) a collecting apparatus which will induce a known volume of the contaminated air through a known quantity of granular activated carbon uniformly over a known period of time, and (2) the facility for recovering the sorbed impurities so as to relate them in terms of concentration per unit of air from which they were extracted, and so as to examine their composition. A diagram and photograph of the collecting unit are illustrated (Figs. 1 and 2) respectively. It consists of dual-perforated, activated carbon-filled, adsorption canisters assembled integrally with a motor-

Fig. I.
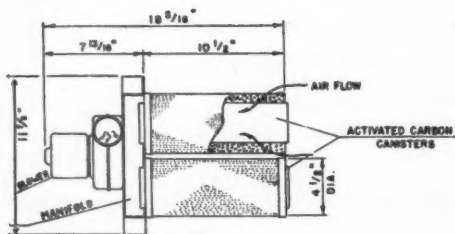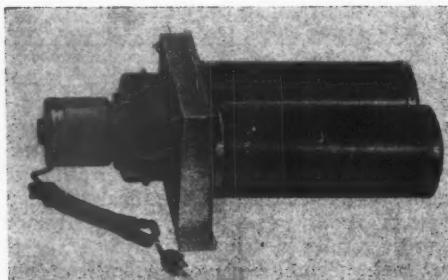
Fig. 2.

driven air blower. The purpose of duplicate canisters is to provide flexibility in or to accelerate testing, as for example, to permit one canister to be continued in operation while the other is under analysis or to permit cumulative collection to be resumed after such analysis indicates it advisable. The design of the collecting unit is such that 40 cu. ft./min. (1130 l./min.) of contaminated air can be drawn through a continuous, uniformly dense 0.7 in. (1.8 cm.) thick layer of 6-14 mesh granular activated carbon at a linear velocity of 25 ft./min. (7.62 m./min.)—well within critical limits of odor break-through.[4] By operating the collecting unit continuously in a contaminated atmosphere for a known duration, the total volume of air that has passed through the carbon in that elapsed time is known. Likewise, the adsorbable impurities entrained in that volume of air will have been collected by the carbon. The canisters are then separated from the unit, sealed and returned to the laboratory for reactivation, i.e., the extraction of adsorbed impurities. Such analyses may be simply quantitative or both quantitative and qualitative depending on the purpose.

While activated carbon, unlike polar sorbents such as silica gel or alumina, has no retentivity for water vapor and the presence of water vapor in no way affects its collecting effectiveness, it is, however, necessary to discount for the water vapor present in the carbon to arrive at a true quantitative determination for non-aqueous impurities. Since the collecting unit is so designed that a uniform rate of air flow and identical duration of contact between air and carbon are insured, the distribution of sorbed impurities in the carbon will likewise be uniform. This enables the carbon to be divided into several convenient samples for distinct parallel determinations. Thus one sample may be used to establish moisture content while another is used to desorb non-aqueous organic substances. Actually, as will be explained, the latter operation establishes total adsorption, the ratio or proportion of non-aqueous organic substances being obtained simply by subtraction. All quantitative determinations are made in terms of weight per unit weight of base carbon.

Analytical Methods and Procedures

THE ANALYSIS of the carbon exposed as previously described to a contaminated atmosphere should provide the following: (1) The average concentration of adsorbable gaseous impurities that prevailed in the atmosphere for the duration of the test; (2) The chemical nature of these impurities and their contribution to odor intensity, toxic effect, if any, and the like; (3) Samples of the collected impurities for further examination where this may be deemed necessary or advisable.

Vapor concentrations are usually expressed either in parts of vapor per million parts of air by volume (p.p.m.) or in pounds of vapor per million cubic feet of air. With the procedure described herein, the latter can be determined directly by the formula:

$$Cw = \frac{1.67 \ (10)^4 \ aw}{rh} \qquad (1)$$

where a = proportion of adsorbed non-aqueous matter by weight of carbon

w = weight of carbon in pounds

r = blower air delivery in cu.ft./min.

h = time of operation in hours

C_w = concentration of impurity in lbs. per million cu. ft.

To determine the concentration in p.p.m. by volume requires that the molecular weight of the non-aqueous matter be known. Then, at normal atmospheric conditions of 70°F. (21.1°C.) and 760 mm. (Hg) barometer:

$$C_v = \frac{C_w \times 386}{mol.\ wt.} \quad (2)$$

where C_v = Concentration by volume (p.p.m.)

For actual collection the unit is placed in the atmosphere to be analyzed and the motor is connected to a source of 110 volt, 60 cycle current and allowed to operate continuously during the test period. As obvious cautions, when the collecting unit is operated outdoors, it must be sheltered against precipitation, and, where dust in quantity likely to clog the canister perforations or carbon bed may be anticipated, suitable filters in a frame surrounding the canisters should be used. In the latter case blower air delivery (r) will differ from the rated capacity and must be determined at the beginning and end of the test. This may be conveniently done by measuring the average linear air flow rate from the nozzle (orifice area 0.0247 sq. ft.) obtained from five anemometer readings—one reading at the center of the orifice, and the other four at the three, six, nine, and 12 o'clock positions of the orifice cross section. For this collecting unit, it is convenient to use the Alnor Velometer (Illinois Testing Laboratories, Chicago) with No. 2220 Jet. Then $r = 0.0247 \times$ average Velometer reading in ft./min. The mean of initial and final values of r may then be used in Equation (1).

As already stated, the determination of the adsorbed non-aqueous impurity (a in formula (1)) requires two steps—first, the determination of the total adsorbed matter and, second, the moisture determination. The difference represents the non-aqueous impurity. For the determination of the total adsorbed matter, the following laboratory procedure and equipment are recommended. A constant supply of low pressure dry saturated steam controlled by a valve to a flow rate of approximately five pounds

per hour is equipped with a trap at its entry to a superheater. The superheater should be adequate to heat this steam flow rate to at least 400°C. A sampling tube constructed of heat resistant alloy tubing approximately 9.5 cm. inside diameter, 20 to 30 cm. long, is supported vertically and flanged at the top to permit filling with the carbon sample, and constricted at the bottom for connection to an outlet tube or pipe leading to a condenser. The sampling tube should contain a screen one-half inch from the bottom to support the carbon sample and, preferably, a one-quarter inch thermometer-well in the center for inserting a thermometer or thermocouple to indicate carbon temperature during steaming. The outside of the tube should be wrapped with sheet mica, then wound with 1.7 ohms per foot resistance Nichrome wire and finally covered with one or more inches of magnesia insulation. This will permit the carbon sample to be heated externally while superheated steam is passing through it. It is possible to dispense with the electrical resistance heating if the steam superheater can deliver steam at about 600°C. Any suitable surface condenser may be used for condensing the effluent steam.

The total adsorption is obtained by filling the sampling tube with a 100 to 200 gram carbon sample accurately weighed to at least within 0.1 grams, connecting the tube to superheater and condenser, introducing the steam and adjusting both the steam and tube temperature to approximately 350°C. (662°F.). The precise rate of steam flow is optional within the capacity of the condenser. The time required for total steaming will vary appreciably depending largely on the nature of the adsorbed impurities. In any event, the steaming should be continued until the condensate is substantially clear and odorless. This may require several hours and an ultimate temperature of 1000°F. (538°C.) or over. When the steaming has been completed, the sample is poured from the hot tube into a jar, sealed and allowed to cool. It is then dried to constant weight at 105°C.

For the determination of water, an accurately weighed 50 gram sample of the unused carbon is placed in a 500 ml. flask and covered with 100 ml. of dry technical

xylene. The flask should be connected, preferably, with ground glass joints, to a Stark & Dean ASTM water test distilling trap and a reflux condenser. The mixture is then boiled until all of the water has been collected by the trap where its volume may be read off directly. The factor a in Equation (1) may then be obtained by:

$$a = x\,y - 1 \quad \text{where} \qquad (3)$$

$$x = \frac{\text{orig. wt. of steamed sample}}{\text{final wt. of steamed sample}}$$

$$y = 1 - \frac{\text{wt. of water}}{\text{orig. wt. of moisture sample}}$$

To clarify the preceding operations, the following actual example is presented:

A collecting unit containing three pounds of activated carbon was operated in an atmosphere contaminated with hydrocarbons, mercaptans and organic sulfides at a flow rate of 40 cu. ft./min. (1130 l./min.) for 300 hrs. Steaming of a 150 gram sample of the carbon yielded 127.1 grams of reactivated carbon. Under xylene moisture test, a 50 gram sample of the carbon yielded 6.0 ml. of water. What was the degree of atmospheric contamination?

Solution:

From Equation (3):

$$a = \frac{150}{127.1}\left(1 - \frac{6.0}{50}\right) - 1 = 0.039$$

And from Equation (1):

$$Cw = \frac{1.67\,(10)^4 \times 0.039 \times 3}{40 \times 300} = 0.16 \text{ lb. impurity per } 10^6 \text{ cu. ft. of air.}$$

Assuming the average molecular wt. of the aggregate impurity is 100, then concentration by volume from Equation (2):

$$Cv = \frac{0.16 \times 386}{100} = 0.62 \text{ p.p.m.}$$

For additional qualitative analyses, where desired, the following procedures are suggested. The resultant condensate from the steam reactivation described usually consists of an aqueous and an oily layer. It is, therefore, practicable to make qualitative determinations from this condensate for the following:

On the aqueous layer:

aldehydes	(fuchsin)
amines	(KI-NaOCl, Sanchez reagent[6])
ammonium	(Nessler's reagent)
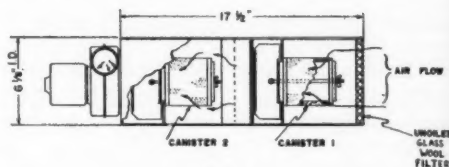
Fig. 3.

halides	(silver nitrate)
nitrates	(diphenylamine sulfate)
pH	(universal indicator)
phenols	(4-aminoantipyrine[5])
sulfates	(barium chloride)
sulfides	(lead acetate)
sulfur dioxide	(odor, or I_2 in KI)

On the oily layer:

esters	(vanillin in sulfuric acid, Takahashi reagent[7])
unsaturation	(bromine)

Such and other tests as may suggest themselves to the analytical chemist will indicate the general nature of the atmospheric impurities adsorbed.

Table II exhibits typical result of actual analyses. The three results for outside urban atmospheres show that sulfur dioxide is a major pollutant, and figures for volume concentration of pollution based on this gas are therefore listed. It is interesting to compare these figures with those obtained by research groups using other analytical methods.[1] The latter findings showed that the average sulfur dioxide concentration within five miles of the center of Pittsburgh (1936-7) was 0.078 p.p.m., with maximum of 0.897 p.p.m. For a less contaminated city (Washington, D.C.) average sulfur dioxide concentration near the center was 0.014 p.p.m., with maximum of 0.290 p.p.m. Such concentrations are similar in magnitude to the values reported in this paper.

The time required for sampling varies within very wide limits, just as does the degree of gaseous pollution in different environments.

Efficiency Evaluation of Carbon Canisters

THE APPARATUS shown in Fig. 3 includes two canisters of construction similar to that previously described, arranged in series and for like conditions of air flow through the carbon beds. This arrangement can be used to measure the adsorp-

TABLE II.
DETERMINATIONS OF GASEOUS AIR POLLUTIONS

Location and operation of collecting unit	h (hours)	average w/r (lb.-min./ cu. ft.)	a	Cw (lb./million cu. ft.)	Remarks
Outside air near New Kensington, Pa., 1949	4,500	0.06	0.031	0.007	Sulfur dioxide, amines and unsaturated oils detected. $Cv = 0.042$ p.p.m. based on SO_2.
Outside air, Los Angeles, Calif., Summer, 1950	2,320	0.10	0.0416	0.060	Sulfur compounds, nitrates, unsaturated oils. $Cv = 0.18$ p.p.m. based on SO_2.
Outside air, sampled in factory district, N.Y., N.Y., Jan., 1950	408	0.06	0.075	0.18	Sulfur dioxide, nitrogen compounds. $Cv = 1.1$ p.p.m. based on SO_2.
Inside air, lubricating oil testing laboratory	100	0.06	0.179	1.79	Unsaturated oils.
Exhaust air from oxidation ("blowing") of soy bean oil	0.75	0.035	0.186	140	Unsaturated aldehydes, unsaturated oils, ammonium ion. $Cv = 800$ p.p.m. based on acrolein.

tion efficiency of the canisters for typical organic vapors. Referring to Figure 3, and assuming that efficiencies, E, of canisters 1 and 2 are equal in the range of saturation below about 15% by weight of carbon, it can be shown that:

$$E = \frac{a_1 - a_2}{a_1} \quad (4)$$

where a_1 and a_2 are the proportionate saturations of carbon in canisters 1 and 2.

Since the efficiency determinations discussed below were done under laboratory conditions where carbon weights were carefully controlled, and since it was not necessary to isolate the adsorbates, a weight increase method was used to determine a_1 and a_2.

The test liquids were evaporated in humid air (simulating possible adverse field conditions) and the vapors were allowed to flow through the canisters as shown in Figure 3. At the end of a period of adsorption, weight increase and moisture content were measured, and proportionate saturation was calculated (similar to Equation 3) as

$a = w z - 1$ where   (5)

$w = \dfrac{\text{wt. of saturated carbon}}{\text{wt. of fresh, dry carbon}}$

$z = 1 - \text{final moisture ratio}$

Results, shown in Table III, indicate that the assumption of efficient vapor adsorption using suitably activated carbon in the canister apparatus, even in a humid atmosphere, is fully justified.

Discussion

TWO QUESTIONS may be raised, first, how much oxidation or decomposition takes place at the carbon surface during the collecting operation and, second, how much hydrolysis occurs during the steam reactivation.

Oxidation at the carbon surface during the operation of the collecting unit is apparently insignificant. This is evident from extensive experience with activated carbon used in air purification. Analysis of the sorbate of such carbon, even after a year or more in service in urban industrial atmospheres, reveals appreciable quantities of unoxidized SO_2 and only small amounts of sulfates. Similarly, the analyses of substances adsorbed on carbon used for air purification in fruit storage has always

TABLE III.
EFFICIENCY DATA

Test Vapor	Canister	Wt. fresh carbon, g.	Wt. satd carbon, g.	Final Moisture Ratio	a	E
Carbon tetrachloride	1	179.7	194.7	0.0325	0.0483	
	2	179.4	185.6	0.0323	0.0012	97.5%
Naphtha	1	170.7	182.2	0.0125	0.0541	
	2	173.4	175.4	0.0112	0.0002	99.5%
Benzene	1	173.4	180.9	0.0075	0.0354	
	2	177.4	178.4	0.0050	0.0006	98.5%
Chloroform	1	171.4	181.5	0.0050	0.0535	
	2	173.4	174.8	0.0060	0.0020	96.3%
Trichlorethylene	1	176.7	188.2	0.015	0.0491	
	2	181.7	182.9	0.0062	0.0004	99.3%
Sulfur dioxide	1	185.2	192.9	0.0040	0.0374	
	2	184.5	186.3	0.0080	0.0017	95.5%

disclosed the presence of aldehydes despite their readily oxidizable characteristic. This is consistent with the known presence of aldehydes in fruit essences and, likewise, spectrometric identification of aldehyde in apple aroma.[10]

Peroxide linkages are catalytically decomposed in the sorbed state on activated carbon, and compounds containing them are best isolated by low temperature trapping.

Hydrolysis doubtless occurs during the higher temperature period of steaming with effects such as splitting of esters; the initial portion of condensed steam desorbate, however, is not seriously affected. In any case, hydrolysis can be circumvented by substituting vacuum desorption for steam reactivation to recover adsorbed impurities. For vacuum desorption, it is convenient to use a train of three traps, namely, ice-salt; dry ice-Cellosolve; and liquid nitrogen. A minimum 50 gram carbon sample is connected to the train of traps, the system evacuated with a high vacuum pump, the carbon gradually heated to 200°C. or over and pumping continued for several hours. Specific instructions on temperatures and pumping time cannot be given since these will depend on individual conditions and requirements. The organics in the dry ice and liquid nitrogen traps may be subjected to infrared, ultraviolet or mass spectrum examination; the aqueous material in the ice-salt trap should first be extracted with a suitable solvent. Various special determinations may be made directly in the vapor phase during evacuation. For example, selenium sulfide test paper will detect mercury vapor which may be released by the carbon during the process even though the concentration of this vapor in the original atmosphere was far below the limit of sensitivity of the test.

Although this vacuum desorbing technique is ideal for the recovery of samples of the atmospheric impurities for spectrographic analyses, it is not a practical substitute for the steam reactivation method to determine total impurity because the retentivity of the carbon for organic substances is so great that complete degassing

of the carbon would be far too time-consuming. For this same reason, it is not feasible to leach adsorbed substances from the carbon directly with a solvent like, for example, carbon tetrachloride. Such extracts would not produce a representative infrared spectrum. In general, the activity and retentivity of activated carbon for impurities of low molecular weight is limited. However, where determinations of dilute concentrations of such impurities are desired, it is often possible to impregnate the carbon with a specific reactant so as to increase its adsorptive capacity for that particular impurity.

A unique use for the collector unit is with "tracer" techniques. Assume, for example, that it is desired to ascertain whether or not a particular atmospheric contamination emanates from a specific remote plant or process. An adsorbable isotopic tracer can be introduced into the exhaust from the suspected process and the collector unit then operated at whatever point the suspected contamination would prove objectionable and the carbon analyzed for the presence or absence of the tracer substance.

The procedure described in this paper will, incidentally, likewise serve to establish whether activated carbon filtration or some other method of purification would prove practical as a solution to the particular pollution problem.

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Calculation of Counting Statistics

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WITH THE expanding use of radioactive tracer techniques in industrial control and research and the pollution of air and water resources with radioactive materials, it is becoming necessary for public health personnel to understand the calculation of radiation counting statistics. Radioactive decay follows a statistical pattern; to anyone who has listened to a Geiger-Counter or observed the changing lights on a scaler it is obvious that the disintegration pattern fluctuates a great deal.

The lights may stay stationary for a few minutes and then spurt or if a record is kept of the first three or four minutes of counting, the variance in the counts per minute is easily noticed and obviously the longer one counts, the more opportunity there is to "iron out" these fluctuations.

The random counts cn any disintegration process raise the question of the possibility of reaching any accurate decision as to the true counting rate. Valid predictions, within certain limits, can be made by the application of statistics.

To calculate the statistics of the disintegration rate is not simply a matter of determining the statistics of one pattern but of the statistics of two because the total count is equal the sum of the count of the material under study and the count attributed to the background radiation under any particular set of circumstances, and the desired result is, of course, the net count (the total less the background). Background radiation is always present and it is attributed to natural radioactivity in the materials within the range of the counter and cosmic radiation, and follows also a statistical pattern.

Where n = a counting rate (number of counts per interval of time usually expressed as counts/minute) and N = number of counts obtained, and t the time interval, Jarrett[1] has shown the error of the Net Count (Total-Background) to be:

$$y = \sqrt{\left(k\sqrt{\frac{N_T}{t_1}}\right)^2 + \left(k\sqrt{\frac{N_B}{t_2}}\right)^2} \quad (1)$$

Now y = the error or unit normal deviate for which the probability (q) that it will be equaled or exceeded in absolute value is given by

$$q = \sqrt{\frac{2}{\pi}} \int_{k\sqrt{x}}^{\infty} e^{-\frac{y^2}{2}} dy \quad (2)$$

on the assumption of Gaussian distributed errors.

k = a coefficient whose value determines the error in the basic equation $y = k\sqrt{x}$

q = the probability of finding values equal to or greater than x, the true average.

k has the following significant values:

k	q	y
0.0	1.00	—
0.67	0.50	Probable Error, Quartiles
1.00	0.32	Sigma (s)
1.64	0.10	9/10 Error or Reliable Error
1.96	0.05	2s or 3 Quartiles
2.33	0.02	$P_{.02}$
2.58	0.01	$P_{.01}$

Actually x is never known and n = (N/t), the counting rate, is used as an approximation. Thus the error is $y = k\sqrt{\frac{N}{t}}$ and by using the sum difference formulation Equation (1) is derived for the error (y) in terms of k, Total $(\frac{N_T}{t_1})$ and Background $(\frac{N_B}{t_2})$ rates. The disintegration phenomena are actually a *Poission Distribution* but for large numbers they closely approximate *Gaussion Distribution*.

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(a) Showing P.32 for   (b) Showing P.05 for
an error of 1% s   an error of 1% g/10
                              error
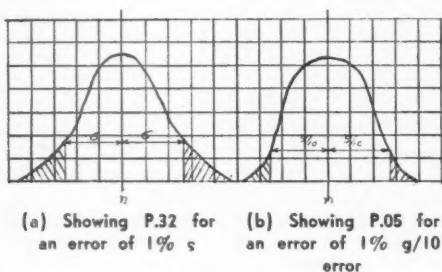
Fig. 1.

Comparing the concentrating effect of increasing the confidence interval

In the frequency distribution pictured in Fig. 1 (a) and (b), the shaded areas indicate the critical region, the unshaded areas are the confidence interval (P). Notice that a shift from a confidence interval of

1% Sigma (s) to 1% 9/10 interval merely lengthens the confidence interval. The percentage expression of the error is used because the disintegration rates in any particular problem vary considerably and it is much easier to express errors as percentages.

Assuming t_1 and t_2 equal to one minute, then $y = k\sqrt{N_T + N_B}$ $\qquad$ (3)

and the error expressed as a percentage would then be:

$$\% \text{ Error} = \left(\frac{y}{N_T - N_B}\right) = k\frac{\sqrt{N_T + N_B}}{N_T - N_B} \quad (4)^2$$

If the ratio of N_T/N_B is set as equal to r, then by substitution—

$$\text{Percentage Error} = \frac{k}{\sqrt{N_B}}\frac{\sqrt{r+1}}{(r-1)}$$
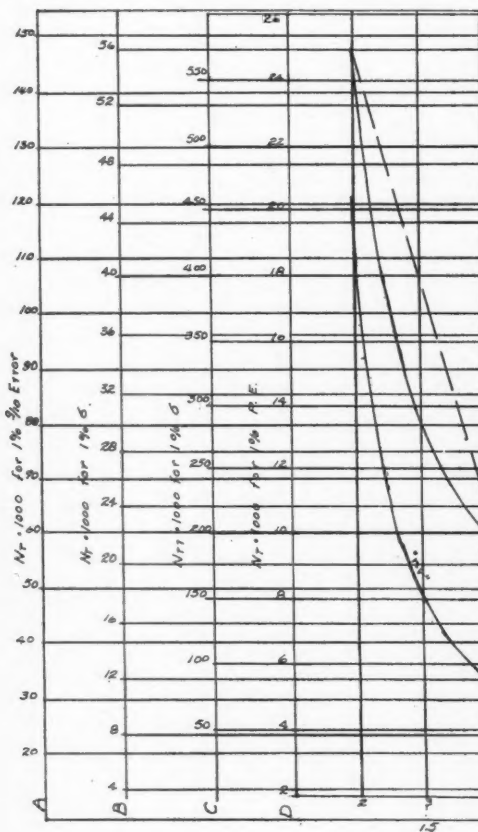
Fig. 2.

Relationship between total counts (N_t) and ratio of total to background (r) for any 1% counting error

$$N_T = \left(\frac{K}{\text{Error}}\frac{\sqrt{r+1}}{r-1}\right)^2 r$$

Error	K	Scale
9/10 E	1.64	A
Sigma	1.0	B & C
P.E.	0.67	D

to change percentage error divided by the $\left(\frac{1}{\text{Error}}\right)^2$

and by rearrangement this equation becomes

$$N_B = \left(\frac{k}{\% \text{ error}} \times \frac{\sqrt{r+1}}{(r-1)} \right)^2$$

Now if N_B is replaced by N_T/r

$$N_T = r \left(\frac{k}{\% \text{ error}} \times \frac{\sqrt{r+1}}{(r-1)} \right)^2 \quad (5)$$

Equation (5) is plotted in Fig. 2 for three 1% errors using three ordinates making possible a direct reading of the most common errors utilized in tracer studies. There is an additional set of scales (rr and N_{TT}) to be used when the ratio r is less than 2. To determine any other percent error, the value of N_T is simply multiplied by one over the square of the desired percentage $\dfrac{1}{\%^2}$.

Examples of Counting Procedure

THE COUNTING error is controlled by the total number of counts or the length of counting. Any error can be achieved within the limits of the other variables in the problem that is being undertaken. For example: If a living material is being counted such as counting of a sample of P^{32} tagged slime, the limit of counting error will be determined by how long this sample can be held under the counting tube without desiccation. Another example would be a very short-lived isotope, such as Na^{23}, which has a half-life of a few minutes. Here its disintegration rate would change so rapidly that it would not be feasible to count over a long period of time; thus the counting accuracy would be limited. In this case, another factor to be considered, as a result of the relatively short half-life, is that the Poisson distribution serves as a reasonable model of the disintegration phenomenon only with isotopes with long half-lives compared to the counting period.

Fig. 3.
Illustrating the relationship between counting error (Ec) to the process error (Ep) and its effect on the total error (Et)

In the use of P^{32}, C^{14}, and I^{131}, the more commonly used isotopes in the laboratory, or in the detection of contaminates from the heavier elements, the half-lives are sufficiently long that this is not a problem.

The first step in counting is to count the background over a long enough period to be assured of a well controlled average.[3] The second step is to make a mental record of the first one or two minutes of the total counting rate of your samples and from this calculate r (ratio of the total to background). Using this in Fig. 2, determine the total number of counts required (N_T) for any desired accuracy Thirdly, count for a period of time slightly in excess of that required to achieve this total count (N_T).

Generally it is well to establish this counting error at such a level that it will not influence the other errors in your experiment. In Fig. 3 is shown a plot of the ratio of counting error to process error vs. the ratio of the total experiment error to process error to assist you in arriving at a desirable counting error level.[4]

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2. Equation (4) can be derived in another fashion. The deviation of n from the true mean x is related to the size of sample as follows:

Error in n in percent of measurement is equal to the formula $= \dfrac{k}{\sqrt{N}}$ This is similar to the Standard Error

Total Percent Error $= \sqrt{\left(\dfrac{k}{\sqrt{N_T}} \right)^2 + \left(\dfrac{k}{\sqrt{N_B}} \right)^2}$

by the sum-difference formula which is equal to equation (4).

3. The error of the background would be (y) $= \dfrac{k}{\sqrt{N_B}}$

$k\sqrt{N_B}$ or the Percentage Error $= \sqrt{N_B}$

4. Precaution in selecting the amount of sample to be counted should be exercised because a minimum registration of 10 counts is required in order to assume the normal approximation. The counting rate should also be such that the process errors (particularly coincidence loss) are not important.

(a) Assume a background count of 16 (counts per minute) and a desired accuracy of 1% P.E. After one minute the count was 43 C/M. What should the total count exceed?

$$r = \frac{43}{16} = 2.6$$

From Fig. 2, Scale D, $N_T = 15,000$

(b) At this counting rate 15,000 counts would take six to seven hours. What accuracy could one get by counting for three hours?

$180 \times 43 = 7750$ counts in three hours

$$\frac{15,000}{7750} = (\frac{1}{\%})^2$$

$$\% = \left(\frac{15,000}{7750}\right)^{\frac{1}{2}} = (1.9)^{\frac{1}{2}} = 1.4\%$$

(c) With $r = 5.1$, what would be the N_T for a 5% 9/10 error?

From Fig. 2, Scale A, N_T 1% 9/10 error $= 50,000$ counts.

N_T 5% 9/10 error $= N_T$ 1% 9/10 error $\times \frac{1}{(5\%)^2} = 2,000$ counts.

(d) With $r = 5.1$, what would be the N_T for a 5% $P_{.02}$?

From equation (5) is can be seen that to change a value of k it is necessary to multiply the value of N_T by (k new/k scale)^2. From example (c), N_T for 5% 9/10 error $= 2,000$ counts.

$$N_T \text{ for 5\% } P_{.02} = 2,000 \times \left(\frac{k\,P_{.02}}{k_{9/10}}\right)^2$$

$$= 2,000 \times \left(\frac{2.33}{1.64}\right)^2 = 4,000 \text{ counts}$$

(e) What would be the absolute value of $P_{.02}$ in example (d) if the total counting (N_T) rate is 51 C/M

$$N_B = \frac{51}{5.1} = 10 \text{ C/M}$$

$N = N_T - N_B = 41$ C/M
$P_{.02} = 5\% \times N = .05 \times 41 = 2.05$ C/M.

Summary

A CURVE has been developed based on a Gaussion Distribution which will enable one to determine the total number of counts required for any desired accuracy expressed in the various commonly employed statistical errors.

D R. JOSEPH A. HUBATA and K. M. MORSE, co-chairmen of the Industrial Hygiene Program Committee for the Midwest Safety Conference, have announced the speakers for the May 6 sessions at the Hotel Sherman, Chicago. The program will be devoted to a practical discussion of the basic problems related to health programs in all sizes of industrial plants. The practical aspects of the subject are to be discussed by an industrial relations expert, an industrial physician, and an industrial hygienist. The program is entitled "A Workable Industrial Health Program" which will be discussed by the following speakers: LUMUEL B. HUNTER, Manager, Industrial Relations, Inland Steel Company; EUGENE L. WALSH, Associate Medical Director, International Harvester Company; and WARREN A. COOK, Director, Division of Industrial Hygiene and Engineering Research, Zurich-American Insurance Companies.

Previewing New Construction
A Technique for the Control of Health and Safety Hazards

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CONSIDERATION of the statistical tables showing the number and distribution of factories in the states of the Union clearly indicates the magnitude of the task confronting the industrial hygiene units in these states and will serve to convince the investigator that the task of the official agency is very large. On the other hand, an analysis of the technical personnel engaged in industrial hygiene activities in the official agencies shows that the agencies in most of the states are comprised of relatively few persons. A recent analysis discloses that more than 85% of the state units are comprised of fewer than 10 persons. To anyone intimately familiar with the field of industrial hygiene, it is inconceivable that such small staffs can adequately deal with the industrial hygiene problems in the large number of factories in their respective jurisdictions. This statement is true of most of the official state agencies.

If we are really interested in meeting the need, we must increase the number and size of industrial hygiene units and find ways in which such units may increase their coverage without so great a demand for staff that it will not be filled in our time.

One way in which coverage may be increased is by the use of factory inspectors connected with state departments of labor or state mining bureaus or commissions. I have, on many occasions, emphasized this approach. It needs no further emphasis at this time. Now, I should like to mention briefly another activity which should serve to broaden the industrial hygiene coverage of units without greatly increasing staff demands and which, at the same time, should serve to improve the quality of the work accomplished. I refer to the examination of plans (a) for factories and (b) for ventilation hazard control systems—both prior to construction.

It is cheaper and easier to correct a potentially unsafe or hazardous condition by altering a few lines on a blueprint before the erection of a building or process than to make the same corrective changes by demolishing walls or piping after they have been built. It takes only a few strokes of pencil and eraser to move a doorway to its proper location for safe exit in the event of fire when this is done at the drawing board before contracts for the building are let. However, once the contractor starts work on the job-site, the same change can become an expensive "extra." Similarly, small scale models or cardboard templates of machines and tanks may be more easily shifted around on a plant layout table than can their full-sized counterparts be shifted around the factory floor to allow their economical and effective exhaust ventilation.

This is, of course, not a revolutionary concept. For years, municipalities have been required to have plans for water works and sewage disposal approved by their State Health Departments Sanitary Engineers prior to construction of the plant. There are very few urban locations in this country where a home, a store or an office building can be built without prior filing and approval of the building plans for conformity with local zoning and building code regulations. In many cities, new or altered plumbing work, boiler plant work and, in some instances, electrical work requires plan filing and approval before starting work.

THE REASONING behind all these requirements is that public safety demands that the appropriate governmental agency be put on notice of each potential source of fire, explosion or epidemic spread of disease, rather than have to ferret each out separately by detective methods. There are, of course, grounds for argument as to what form this notice to the governmental agency

should take. There are those who contend that notice of the start or completion of new work or alteration should suffice. They reason that this takes the detective work out of administering the pertinent regulations without imposing on the owner or builder an obligation to file plans. They argue that any necessity to wait for plan approval before starting work involves a costly delay to both owner and contractor. It is customary in such discussion to cite specific examples of one, two or three months required to obtain plan approval, from the time of filing to the time of final approval. However, delays of this sort are not inherent in a plan approval program. With proper administration, the great majority of plans filed can be processed to approval or disapproval within a period of two weeks after filing. The plan that drags on for two or three months is generally the one that has to be disapproved as originally submitted and then returned to the owner for extensive revision. It is unfair to charge this type of delay to the administrative agency since it is being most effective when it catches proposed installations so far "off-the-beam" as to require lengthy redesign.

The length of time required for obtaining approval is delaying and costly only when it is great with respect to the other time elements of design and construction of a job. A two-week delay would be an obvious impediment to a job that was conceived on Monday, designed on Tuesday and could be built on Wednesday and working on Thursday if plans did not have to be filed and approved in the interim. Fortunately, jobs of this nature are extremely rare. It is much more common that jobs are mulled over for weeks or months, designed over another protracted period of time and then allowed a leisurely halt while contracts can be let, or until the maintenance crew can fit the job into its schedule. Contractors have backlogs of work. They must order-in and await delivery of material and availability of their men and equipment. All these factors result in an interval of months between the concept and start of work on most jobs. In comparison with this time requirement and the delays in the owners and contractors operations,

the week or two needed for plan approval becomes small indeed.

There are few jobs of any consequence that are built without plans. Plans are usually needed to lay out the job and properly guide the builder as to what he has undertaken to construct. Since such plans are usually available even where governmental plan filing is not mandatory, it is only necessary to have two or three additional prints made of the drawing in order to comply with a mandatory filing requirement. There are naturally small jobs that can be built from plans which exist only in the builder's head or from sketches on the back of an envelope. These do require the extra expense of a draftsman's time to comply with a plan filing rule. To this extent, compulsory plan filing tends to be more onerous to the small fellow than the big one. However, experience indicates that the small job usually needs closer scrutiny than the big one, and thus makes it poor public policy to relax any plan filing requirement for small jobs. The reason for this is that a big job is likely to be turned over to trained engineers or designers and, as a result, be well designed. The smaller job that cannot stand the cost of engineering design is more likely to be laid out with design defects than can be caught on plan examination and review.

ANOTHER school of thought goes along not only with the necessity of putting the governmental agency on notice but also of filing plans with that agency. However, they balk at the necessity of having the plans approved by that agency prior to starting work. They count on the natural reluctance of inspectors to correct relatively minor infractions of the regulations governing such work. Yet some operators cut corners and take unfair advantage of their more ethical competitors. Where these short cuts are caught and eliminated at the plan review stage, both the inspector and the builder are put on notice that these minor deviations will not be tolerated, if for no other reason than they violate one of the cardinal reasons for codes, laws, and rules, i.e., elimination of unfair competition at the expense of health and safety.

Codes and rules set up a uniform stand-

ard for all to meet. One paint manufacturer is required to observe the same safety and health precautions in his building, process and operations as any other in the same jurisdiction. His costs and selling price can be lower than his competitors only by a more efficient operation or an inferior product, but not by virtue of a less safe or healthful plant. The latter is by law eliminated as a competitive factor and it is up to governmental agencies administering the pertinent laws and codes to see to it that this condition exists in fact as well as in theory. Mandatory prior approval of new construction affecting safe and healthful operation is the best way we have found to date to make this so.

Administrative officials recognize a subtle difference between a requirement that plans be approved before the construction of any job and a requirement that they be approved before the construction only of jobs for which "corrective orders" have been issued. A "corrective order" is an official notice from a governmental agency that upon inspection a violation of law, code or regulation has been observed and must be corrected. It can only ensue where a physical inspection of the premises has been made. Where there is no concurrent requirement that the enforcing agency must be put on notice of new construction or alteration, the agency is still in the detective business, in that it must be astute enough to send an inspector to the location of the violation. In terms of New York State Labor Department operations, what this means is as follows: There are about 50,000 factories in the state and about 300 factory inspectors or 200 factories per inspector. Some of these factories are so large that it takes one inspector several weeks to complete his inspection; some are the only industry in a community so that even if it is a small factory the inspector has to devote a whole day to its inspection. When it is realized that inspectors must take time from primary field inspections to keep records, make reports, make follow-up visits to check compliance with "Orders" previously issued, make complaint inspections, confer with their supervisors, make special surveys, which are necessary from time to time, and in addition make

such inspections as necessary in several thousand mercantile establishments employing people, it is small wonder that it is not possible to get more than one or two inspections of a factory in any one year. In some areas of the state, where there has been a temporary shortage of inspectors, it has been necessary to have even less frequent inspections.

A conceivable result of having the inspectional work load dictate such infrequent inspections is that a factory installation made during the week after the inspector's visit may wait almost two years before it is seen by an inspector and as much as *three or four years* if it is overlooked on the first inspection. Thus, an unsafe or unhealthful condition can possibly exist for several years before corrective orders are issued for its improvement. Under an administrative program calling for plan approval only during the process of complying with corrective orders, this long-standing technical violation can now be erased by belated compliance after the violation was spotted by routine detective work on the part of the inspection staff. Had it been required that the administrative agency be placed on notice of the new installation, an inspector would have been immediately dispatched to the premises and the corrective order issued immediately. Failure of the owner to notify the agency would have put him in immediate violation of that specific mandate rather than in technical violation with regard to details of his installation or construction. Had plan filing been required prior to *all* installations, even the necessity of issuing the original corrective order would have been avoided, and the over-all cost to the owner and the state minimized.

IN NEW YORK our regulations requiring mandatory prior filing of plans stem from both the Labor Law and the Rules of our Board of Standards and Appeals (known as the Industrial Code) which, under the Labor Law, have the force and effect of law. We in the Industrial Hygiene Division are in the fortunate position of having a considerable hand in the drafting of the Industrial Code. The first drafts of all new codes and code rules are prepared

in our division, and we arrange for and work with the Technical Advisory Committees which the Industrial Commissioner may (and invariably does) appoint to work these first drafts up into finished "Proposed Codes." These "Proposed Codes" are transmitted to the Board of Standards and Appeals, who then have authority to accept, reject or amend the proposal limited only by the restriction that adequate public hearings must be held before promulgation of any rule or code. To date all recent codes promulgated by the Board have required mandatory plan filing in *all* cases prior to construction or installation.

The laws and codes requiring Labor Department preview of new construction cover both structures and processes. Specifically, one series of laws and codes having this provision relate to factory buildings, certain mercantile buildings and places of public assembly; as well as to certain installations therein such as fire alarm signal systems, elevators, dumbwaiters and escalators. Another series of laws and codes relates to dusts, gases, fumes and heat and their control by ventilation. Because these two series are so different, we have separate groups of engineers engaged in reviewing building plans and ventilation plans. Our building plan examination work is done in Albany for upstate counties and at the Empire State Building in New York City for the down state counties (excluding New York City which has its own building plan approval set-up). These offices deal primarily with the architects and engineers who prepare the plans and the local town, village and city building officials who do the local building code enforcement. Our ventilation plan examination work is handled by our Industrial Hygiene Engineers who, working out of offices in New York City, Syracuse and Buffalo, also do the normal field surveying, consulting and sampling common to Industrial Hygiene Engineers in other jurisdictions. They get plans both as the result of corrective orders and compliance with the provisions of law and code requiring plan filing before installation.

One could present the many details of the mechanics of handling plans and the specific provisions of the law and codes but in the final analysis, each jurisdiction must work out these details to fit their own needs. Suffice it to say that after over thirty years of approving plans, we in New York State have developed the mechanics to the point that most situations have become routine. Nevertheless, the judgment of the engineer reviewing the plan can never become routine. Only by employing well-trained men familiar with the latest developments in industrial hygiene and safety, in building construction and industrial ventilation and by allowing them freedom to exercise their judgment, can a plan approval system be a *dynamic* device to improve health and safety conditions. To those who are deeply interested in making industrial hygiene a vital force in the improvement of the working conditions of a really large segment of factory workers, we sincerely urge the employment of measures to widen the area of effectiveness of industrial hygiene units by some such means as cited in these very brief remarks.

Industrial Health Problems in the Rubber Industry

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THE AMERICAN rubber industry is complex and diversified. Its raw materials and products come from, and are used in, many parts of the world. Many of its processes require the use of potentially hazardous materials. Recent years have seen many changes in this industry. One of the most significant of these has been the development of American-made rubbers from domestic raw materials. In 1941 essentially all of the 787,000 long tons of rubber consumed in the U.S.A. were imported natural crude. In 1950, nearly half of the 1,258,000 long tons used came from domestic synthetic production. Many types of American-made rubber are commercially available, but GR-S (Government Rubber-Styrene) is the chief product. Others are butyl, nitrile types, neoprene, and thiokol. In the production of all of them certain health hazards exist. In the processing of them, as well as of natural crude, similar problems arise. A discussion of those relevant to GR-S production, and GR-S and natural crude processing, follows.

I. GR-S Manufacture

THE MANUFACTURE of GR-S rubber consists of copolymerizing two compounds, butadiene and styrene, to form a finely dispersed latex. This is then subsequently coagulated, filtered, dried and baled for processing operations. Various types of GR-S are produced, depending upon the physical properties desired in the final product. This variation requires the use of different operating temperatures and pressures, different butadiene-styrene ratios, various catalysts, modifiers, polymerization accelerators, and anti-oxidants. A flow diagram of the general process is shown in Fig. 1.

BUTADIENE: The butadiene used for GR-S manufacture is the 1,3 isomer, with the formula $CH_2:CH.CH:CH_2$. It is a gas which
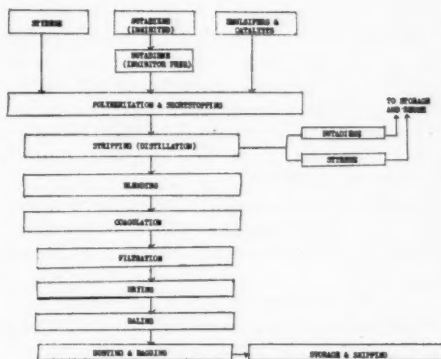
Fig. 1.
Flow Diagram of GR-S Manufacture

liquifies at $-4.4°$ C. It is highly flammable, with an explosive range of 2.0-11.5 percent in air.[1] Because of these physical characteristics, storage and transportation are accomplished under pressure and insulation. Upon its arrival at a GR-S plant, it is handled in a closed system. Necessary precautions must be taken to insure against the possibility of fire and explosion wherever it is used. Butadiene tends to spontaneously form explosive peroxides upon ageing. Hence an inhibitor such as tertiary butyl catechol, must be incorporated into the commercially produced product.[2]

The health hazards of butadiene are mild. It has a narcotic effect at high concentrations, but has little if any cumulative action.[3] Atmospheric concentrations up to at least 1000 p.p.m. can be tolerated for prolonged periods of time without ill effects.

STYRENE: Styrene, $C_6H_5.CH:CH_2$ is a liquid, boiling at 145°C. Its limits of flammability are 1.1% (29.3°C) to 6.1% (65.2°C).[4] As in the case of butadiene, rigid precautions are necessary to protect against fire. Physiologically, styrene does not produce the serious effects of the closely related aromatic hydrocarbon, benzene. No significant changes have been found in laboratory animals exposed to vapor concen-

trations of 650 p.p.m. up to six months[5] but subjective symptoms in humans have been found[3] after several hours' exposure to 800 p.p.m. The vapors become quite irritating above 400 p.p.m. It is therefore desirable to maintain workroom atmospheres below 200 p.p.m.

MINOR COMPONENTS: A large number of substances are used in more or less minor quantities for GR-S manufacturing. Among these are the various catalysts, emulsifiers, polymerization accelerators, short-stopping agents, anti-oxidants, and dusting materials. Fortunately very few of these substances in their specific use present health problems. Exceptions are dinitrochlorobenzene, sodium sulfide, and EFED (triphenyl phosphite).

Dinitrochlorobenzene is a hazardous compound. It is a severe sensitizer and elaborate precautions must be taken to prevent skin contact. If it does occur accidentally, immediate removal from the skin is necessary. In addition to its dermatitis producing potentialities, it is also systemically toxic. The degree of this, however, is not fully established, but is believed to be more severe than nitrobenzene.[6] In the industrial use of this compound, the dermatitis hazard is by far the more important, and because of its severity, more or less controls the systemic hazard automatically.

During the coagulation of the latex, sulfuric acid is used. If sodium sulfide is present, hydrogen sulfide is produced. The high degree of toxicity of this compound is well known. The manufacturing operations at which this evolution occurs are essentially open, and most of them require the installation of process ventilation to satisfactorily control this hazard.

EFED is a relatively new compound industrially. Little is known regarding its toxicity. However, upon hydrolysis phenol is one of the products. This, together with EFED, may be present in the workroom air around the coagulation, filtering, and drying areas in sufficient amounts to require the use of process ventilation.

II. Processing Operations

A LARGE RUBBER industry in its processing of crude rubber into finished products uses a tremendous variety and quantity of different materials. An attempt has been made to list these in the accompanying table. This list is obviously intended to be typical of the industry and is not complete for any one manufacturer. Professional industrial health personnel will recognize here many materials with well-known physiological characteristics, as well as many about which little or nothing is known. It is because of the use of this vast array of substances, as well as the constant introduction of new ones, that industrial hygiene in the rubber industry is a necessity.

It obviously is impossible to discuss in detail the health hazards of any great number of these materials. Many of course, are relatively innocuous and require no discussion. Others present numerous problems. From the standpoints of severity of hazard, number of personnel exposed, and quantity of material used, the solvents as a class are of major importance. These I shall attempt to discuss briefly. It should be realized that in addition to the various systemic problems associated with the use of these solvents, there is always the problem of dermatitis. This in many cases is the more difficult of the two to control.

AROMATIC HYDROCARBONS: Benzol, toluol, and xylol (the names for the commercial grades of benzene, toluene, and xylene) are used quite extensively as solvents for rubber cements and for tackifying purposes. By far the most important of the three from the standpoint of hazards to health is benzol, although the other two are not without danger. The literature contains a large amount of information on physiological effects of these materials, some of which is conflicting, to say the least. The chemical formulas of the three compounds are C_6H_6, $C_6H_5 \cdot CH_3$, and $C_6H_5(CH_3)_2$. Their boiling points are 80.2°C, 110.4°C, and 138°C to 144°C respectively. All are flammable, with quite low explosive levels, and with flash points of—12°C, and 4°C, and 18° to 20°C, respectively. The commercial grades of each contain as impurities minor percentages of each of the other two, and xylol contains all three of the xylene isomers (meta, ortho, para).

Acute poisonings rarely result from these solvents, but chronic poisoning is a real probability. This is characterized chiefly

COMPONENTS USED IN THE MANUFACTURE OF RUBBER PRODUCTS

RUBBER

1. *American Made*
   - GR-I   Nitriles
   - GR-S ("Hot" and "Cold")   Neoprene
   - GR-S Latex   Hycar Pa   Thiokol
2. *Natural*
   - Fine Para   Pale Crepe
   - Guayule   Ribbed Smoked Sheets
   - Natural Latex
3. *Reclaim*
   - Inner Tube (Natural Butyl)   No. 2 Peel
   - Mechanical Blend (Black, Light)   Pure Gum
   - No. 1 Peel   Whole Tire

TEXTILES

Chafers (Primarily Cotton)
Hose and Blet Ducks (Rayon, Cotton, Nylon)
Liners (Primarily Cotton)
Tire Cord (Rayon, Cotton, Nylon)

VULCANIZING AGENTS

Ethyl Tuads (Tetraethylthiuram Disulfide)
Methyl Tuads (Aetramethylthiuram Disulfide)
Selenac (Selenium Diethyldithiocarbamate)
Selenium   Sulfur
Tellurac (Tellurium Diethyldithiocarbamate)
Tellurium   Tetramethylthiuram Monosulfide

ACTIVATORS

Barak (Dibutyl Ammonium   Para-Amino Phenol
   Oleate)   Polyac (Polydinitrosobenzene)
Calcium Hydroxide   Litharge   Sodium Acetate
Stearic Acid
Magnesium Oxide   Triethanolamine
M.O.D.X. (Mixed Organic
   and Inorganic Acetates)

RETARDERS

Antiscorch Essen (Phthalic   Phthalic Anhydride
   Anhydride)   Salicylic Acid
Benzoic Acid   Delac J—   Trichloro Melamine
Vultrol—Diphenyl Nitroso
   Amine

SOLVENTS

Acetone   Amyl Acetate   Isopropyl Acetate
Benzol   Isopropyl Alcohol   Kerosene
Butyl Acetate   Butyl Alcohol   Methyl Alcohol
Carbon Tetrachloride   Methyl   Ethyl Ketone
Ethyl Acetate   Ethyl Alcohol   Methyl Isobutyl Ketone
Ethylene Dichloride   Monochlorobenzene
Gasoline (Unleaded)   Propylene Dichloride   Toluol
Heptane   Hexane   Trichloroethylene   Xylol

STIFFENERS AND ANTI SOFTENERS

Glue   Shellac

COLOR PIGMENTS

Aluminum Powder   Permanent Green
Antimony Sulfide   Permanent Orange
Benzidine Orange   Permanent Red
Benzidine Yellow   Red Iron Oxide
Cadmium Lithopone   Red Lithol Toner
Cadmium Selenide   Rubber Green
Cadmium Sulfide   Titanium Dioxide
Chrome Green   Ultramarine Blue
Lead Chromate   Yellow Iron Oxide
Monastral Green

INERT FILLERS

Calcium Silicate   Cork   Ground Whiting
Hard Clay   Precipitated Whiting   Soft Clay

ACCELERATORS

Aldehye Ammonia (Ammonia-Acetaldehyde Condensation
   Product)
Altax (Benzothiazyl Disulfide)   Butyl Eight
Butyl Zimate (Zinc Dibutyldithiocarbamate)
Captax (Mercaptobenzothiazole)
Dibenzo GMF (P, P' Dibenzoyl Quinonedioxime)
Diortho Toylyl Guanadine   Diphenyl Guanadine
Erie (Bis 4, 5 Dimethyl-Thiazyldisulfide)
Ethyl Tuads (Tetraethylthiuram Disulfide)
Ethyl Zimate (Zinc Diethyldithiocarbamate)
Ethylac (2-Benzothiazyl-N,N-Diehyl Thiocarbamyl Sul-
   fide)

GMF (P-Quinonedioxime)
Guantal (Diphenyl Guanidine Phthalate)
Hepteen, Hepteen Base (Heptaldehyde-Aniline Conden-
   sation Product)
Hexa (Hexamethylene Tetramine)
Ledate (Lead Dimethyldithiocarbamate)
Mercaptothiazoline
Methyl Tuads, Monex, Thionex (Tetramethylthiuram
   Disulfide)
Methyl Zimate (Zinc Dimethyl)
Methylene Para Toluidine
Na-22 Accelerator (2-Mercaptoimidazoline)
Para Nitrosodimethylaniline   Polyac
Potassium Pentamethylene Dithiocarbamate
Pullman (Butyraldehyde-Aniline Condensation Product)
Safex (2, 4-Dinitrophenyl Dimethyl-Thiocarbamate)
Santocure (Benzothiazyl-2-Monocyclohexyl-Sulfanamide)
SPDX (Lead Dithiocarbamate)
Tetrone (Cipentamethylene Thiuram Tetrasulfide)
Texas (Mixed Mercapto Alkyl Thiazole)
Thiocarbanilide
Trimene, Trimene Base (Formaldehyde-Monethylamine
   Condensation Product)
ZBX (Zinc Butyl Zanthate)

FATTY ACIDS

Cottonseed Fatty Acid   Low Acid Palm Oil
Fatty Acid Ester   Stearic Acid
Lauric Acid   Wool Grease

REINFORCING FILLERS

Barytes, Blanc Fixe
Channel Carbon Blacks (Various Types)
Furnace Carbon Blacks (Various Types)
Lithopone   Zinc Oxide
Precipitated or Fumed Silica ("White Carbon Black")

ANTI-OXIDANTS OR AGE RESISTORS

Agerite Alba (Monobenzyl Ether or Hydroquinone)
Agerite Powder (Phenyl Beta Naphthylamine)
Agerite Resin (Polymerized Aldol Alpha Naphthylamine)
Agerite Resin D (Polymerized Trimethyl Dihydroquino-
   line)
Agerite White (Di-Beta Naphthyl Para Phenylene-
   diamine)
BLE (A Ketone-Amine Reaction Product
Flectol B (Condensation Product of Acetone and Aniline)
Flectol H (Condensation Product of Acetone and Aniline)
Flectol White (1, 1-Di Para Hydroxyphenyl Cyclohexane)
Hoboken (Diphenyl Para Phenylene Diamine)
Iso Proposy Diphenylamine
Neozone D (Phenyl Beta Naphthylamine)
PBNA (Phenyl Beta Naphthylamine)
Santoflex B (Condensation Product of P-Aminodiphenyl
   and Acetone)
Stalite (Mono and Diheptyl Diamines)

DUSTING MATERIALS

Corn Starch   Mica   Soapstone   Talc
Potato Starch   Zinc Stearate

PLASTICIZERS AND SOFTENERS

Asphaltum Oil   Bardol   Paraffin Wax
Black Petrolatum   Paraflux   Pine Tar
Coal Tar Base Oil   Soft Asphalt   Soft Coal Tar
Dibutyl Phthalate   Dipentene
Extending Resin   Factice   Soft Cumar   Stabelite
Hydrogenated Rosin   Syncera Wax   Tergum
Mineral Rubber   Tricresyl Phosphate
Paraffin Base Oil
     R.P.A. #3 (Xylyl Mercaptan in Inert Oil)

WETTING AGENTS

Alphasol OT   Aquarex D   Orvus Paste   Tergitol #7
Nacconol   Turkey Red Oil

MISCELLANEOUS

Ammonia   Asbestos   Graphite
Calcium Chloride   Caustic Soda   Hydrochloric Acid
Copper Cyanide   Chlorine   Pumice   Soda Ash
Cobalt Stearate   Sodium Bicarbonate
Diatomaceous Earth   Sodium Cyanide   Sulfuric Acid
Diazo Amino Benzene   Tri Sodium Phosphate
Formalin   Glycerin   Zinc Cyanide   Zinc Chloride

by a damage to the blood forming processes, and may be permanently injurious or fatal. The symptomatology and treatment has been adequately discussed previously[7] and will not be repeated here. The working environment of the employee must be so controlled that excessive exposure to any of these solvents will not occur. Suggested maximum vapor concentrations are 50 p.p.m. for benzol and 200 p.p.m. for toluol and xylol. In addition, the personnel so exposed should be examined regularly, with a complete blood count made at two or three month intervals. Any abnormal trend in one or more of the blood values should indicate the need for possible removal of the individual from exposure and correction of operating procedures.

PETROLEUM HYDROCARBONS (DISTILLATES): Members of this group of solvents which find common usage in the rubber industry are gasoline (unleaded), hexane, heptane, and kerosene. Hexane and heptane are chemical compounds, with chemical formulas of $CH_3.(CH_2)_4.CH_3$ and $CH_3.(CH_2)_5.CH_3$ respectively. Gasoline and kerosene are commercial blends of a number of different compounds. Boiling points range from 70°C upwards. All are flammable, with low explosive ranges and with flash points beginning at −45°C.

.. The physiological action of these solvents is that of a narcotic. They are mildly toxic as compared to the aromatic hydrocarbons. However, some, particularly gasoline, may contain appreciable quantities of benzol, and if so the handling hazard will be proportionately increased. They possess irritant properties to the eyes and respiratory passages, which in most cases will serve as a controlling indicator of excessive exposure. Atmospheric concentrations in the 500-1000 p.p.m. range can be tolerated with safety, unless one or more of the aromatic hydrocarbons as impurities are present in appreciable quantities. In this case a working level based upon the specific aromatic hydrocarbon concentration present should be used.

KETONES: The ketones are excellent rubber solvents, and especially find uses in the processing of the nitrile rubbers. Acetone, methyl ethyl ketone (butanone), and methyl isobutyl ketone are of the most

importance. Their chemical formulas are: acetone—$CH_3.CO.CH_3$; methyl ethyl ketone —$CH_3.CO.C_2H_5$; and methyl isobutyl ketone—$CH_3.CO.C_4H_9$. Their boiling points range from 56°C to 118°C, respectively. All are flammable with flash points ranging from −18°C to 23°C.

The toxicities of these compounds are mild. In high concentrations, their effects are those of a narcotic. Chronic intoxication is unknown. Atmospheric concentrations much in excess of 500 p.p.m. for acetone and 200 p.p.m. for methyl ethyl ketone and methyl isobutyl ketone produce uncomfortable eye and respiratory irritation and should be avoided.

CHLORINATED HYDROCARBONS: Of this general class of solvents, carbon tetrachloride, ethylene dichloride, trichloroethylene, perchloroethylene, propylene dichloride, and monochlorobenzene find the most use in the rubber industry. This use varies. Some are used as rubber solvents, others as degreasers, and as fire extinguishing agents. Carbon tetrachloride, trichloroethylene, and perchloroethylene are nonflammable. The three others are. Their chemical formulas and boiling points are as follows:

Carbon tetrachloride—CCl_4. 77°C.

Ethylene dichloride, (1,2 dichloroethane) —$Cl.CH_2.CH_2.Cl$. 84°C.

Trichloroethylene—$CHCl: CCl_2$. 87° C.

Propylene dichloride (1,2 dichloropropane)—$CH_3.CHCl.CH_2Cl$ 97°C.

Perchloroethylene (tetrachloroethylene) —$Cl_2C: C: Cl_2$. 121°C.

Monochlorobenzene—C_6H_5Cl. 132°C.

The chlorinated hydrocarbons possess varying degrees of toxicity. Of the above named, carbon tetrachloride is the most severe. Serious injury and death may result from exposure. Individual susceptibility varies widely. It produces chronic effects, primarily to the kidneys and the liver. It is an insidiously dangerous solvent and requires careful handling. Trichloroethylene and perchloroethylene are considerably less toxic than the others mentioned above, but still need to be handled with discretion. Unfortunately, there are no reliable simple indices useful for clinical evaluations of over-exposure to the chlorinated hydrocarbons. Rigid inspections of

the working environment are necessary to maintain atmospheric concentrations at safe levels. These vary with the individual compounds, ranging from 50 p.p.m. for carbon tetrachloride to 200 p.p.m. for perchloroethylene. The treatment of cases of poisoning has been discussed elsewhere.[7]

ALCOHOLS: Alcohols used by the rubber industry are methyl, ethyl, isopropyl, n-butyl, and n-amyl. The chemical formulas and boiling points of these compounds are as follows:

Methyl—CH_3OH. 65°C.
Ethyl—C_2H_5OH. 78°C.
Isopropyl—$(CH_3)_2CHOH$. 83°C.
n-Butyl—$C_2H_5.CH_2.CH_2OH$. 117°C.
n-Amyl—$CH_3.(CH_2)_3.CH_2OH$. 138°C.

All are inflammable, with flash points of 12°C and upwards.

From the standpoint of industrial health hazards, those of most significance are methyl, butyl, and amyl. Methyl alcohol produces its ill-effects primarily on the optic nerve. Accidental and suicidal poisonings from the drinking of methyl alcohol (wood alcohol) frequently occur, but industrial poisonings are rare. Atmospheric concentrations should generally be maintained below 200 p.p.m., and skin contact prevented.

Both n-butyl and n-amyl alcohol are inherently more toxic than their lower homologs.[8] However, because of their lower volatilities, and their irritant properties, little hazard is encountered in their use. Sterner[9] has reported, in a ten year study of workers exposed to butyl alcohol vapors, no ill effects at levels up to 100 p.p.m. Above this level irritation existed. He suggests 100 p.p.m. as a safe working level.

ACETATES: Acetates are useful as general rubber solvents. Those of primary importance are methyl, ethyl, n-propyl, isopropyl, n-butyl and isoamyl. Their chemical formulas and boiling points are as follows:

Methyl—$CH_3CO_2.CH_3$. 57°C.
Ethyl—$CH_3.CO_2.C_2H_5$. 77°C.
N-propyl—$CH_3.CO_2.CH_2.C_2H_5$. 102°C.
Isopropyl—$CH_3.CO_2.CH(CH_3)_2$. 88°C.
N-butyl—$CH_3.CO_2.CH_2.CH_2.C_2H_5$. 125°C.
Isoamyl—$CH_3.CO_2.CH_2.CH_2.CH.(CH_3)_2$. 142°C.

All are flammable with flash points of 9°C and upwards.

As a group these compounds are only mildly toxic, and their industrial health hazards are few. The vapors are irritating in concentrations above 200 p.p.m. The suggested maximum working levels are based largely on this irritating characteristic. They are considered to be among the safest of the solvents.

Summary

THE PRECEDING discussion should not convey an idea of hazardous working conditions existing in the rubber industry. However, it does indicate a few of the problems which may arise if improper handling precautions are used. We believe we have done, and are doing, a good job. However, ours is a rapidly changing industry. It is not only a huge consumer of chemicals, but a large producer as well. New materials, with their unknown hazards, are constantly being developed. Toxicological and industrial hygiene studies for them must likewise be made if they are to be used safety.

This offers a challenging opportunity for industrial health.

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The President's Page

Educational Standards for Industrial Hygiene Personnel

THE REPORT of the Education Committee of the American Industrial Hygiene Association was published in the December, 1951 issue of the Quarterly. This report was carefully considered by the Board of Directors and is now presented to the membership of the Association for their consideration.

The majority of the persons who are working in industrial hygiene at the present time entered this field through other professions and gained their knowledge of the subject by practical experience. However, industrial hygiene now has become well enough established to stand as a profession in itself. Specialized scientific and technical information has been accumulated and administrative procedures have been developed. As a result of this early work, the type of basic education and specialized training necessary for work in industrial hygiene has been crystallized, and it is now time for educational standards to be outlined.

There are several reasons why educational requirements and standards for industrial hygiene personnel should be recommended.

In the first place, young persons desiring to enter the field of industrial hygiene do not know the type of education which will fit them for such work. With the exception of the few graduate schools which offer specific courses in industrial hygiene, the universities and colleges are not familiar with the type of education which is necessary for this work. In fact, many, if not most, of the undergraduate colleges and universities are not aware of this specific field. It is believed that more persons will be attracted to work in industrial hygiene if the educational qualifications at the undergraduate, as well as at the graduate levels, are determined.

In the second place, industries, insurance companies, governmental agencies and others are seeking trained personnel for work in industrial hygiene; yet there are no standards by which these organizations can gauge the educational qualifications of candidates for these positions.

The third and most important reason for outlining a program and for setting standards of education is to maintain industrial hygiene work at a high professional level. Only by assuring that industrial hygiene personnel have a certain level of education can this profession command the respect and maintain the position which it has attained.

If educational standards for industrial hygienists are to be set, the agency which should determine these standards is the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION through its Education Committee. In preparing the report the Committee felt that the objectives and responsibilities of industrial hygiene had been sufficiently established to determine the general basic requirements for specialists in this field. On the other hand, because of the varied phases of industrial hygiene and the continual new developments in this subject, it did not seem desirable at this time to present a detailed educational program.

The individual members of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION are the persons who have developed this profession, hence, it is their personal responsibility to set and to maintain the standards of their profession. The future progress and the status of industrial hygiene depends largely on the standards of education which are required. With this in mind, we ask you to consider the report of the Education Committee and to contribute your ideas and suggestions.

—ANNA M. BAETJER, SC.D.

American Industrial Hygiene Association

Program of the Annual Meeting
April 21 to 24, 1952
Netherland Plaza Hotel
Cincinnati, Ohio

Monday Afternoon, April 21

INDUSTRIAL Hygiene Tours: Field trips will be held Monday afternoon. Chartered buses will leave the Netherland Plaza Hotel at 1:30 P.M. The tours will last approximately three hours, including travel time from the hotel and return:

1. Allis-Chalmers Manufacturing Company.
2. Cincinnati Milling Machine Company. (Evidence of citizenship required.)
3. Hilton-Davis Chemical Company. (Limit 30.)
4. Kettering Laboratories of Applied Physiology.
5. National Distillers Products Corporation. (Limit 75.)
6. Proctor and Gamble.
7. U.S. Public Health Service, Division of Occupational Health Laboratories.
8. Sightseeing tour of the city, including one or two stops at points of interest.

Tuesday Morning, April 22

JOINT Session A.I.H.A.—A.C.G.I.H. Session Arrangers: WILLIAM G. FREDRICK, SC.D.; JOHN C. SOET. Subject: "Air Pollution Control"—(Detroit, Michigan —Windsor, Ontario). Sub-title: "The Integration of Community Resources."

Co-Chairmen: LESTER M. PETRIE, M.D.; ANNA M. BAETJER, SC.D.

"Outline of the Problem"—GEORGE D. CLAYTON.

"How to Establish the Program—Statistical Considerations"—D. M. GAFAFER.

"Environmental Studies—General Area Sampling"—MORRIS KATZ, PH.D.

"Environmental Studies—Specific Sampling Problems" —J. C. RADCLIFFE.

"Environmental Studies—Meteorological Aspects."

"Environmental Studies—Health Aspects"—JOSEPH MOLLNER, M.D.

Tuesday Afternoon, April 22

GENERAL Session—Co-Chairmen: ALLEN D. BRANDT, SC.D.; EDGAR C. BARNES.

Welcome—ANNA M. BAETJER, SC.D.

"The Problem of Occupational Health in the Development and Expansion of Industry in Western United States"—HENRY N. DOYLE.

"Arsenic and Antimony Poisoning In Industry"—L. E. RENES.

"Experience Accumulated in Three Years of an Occupational Medical Clinic"—HARRIET L. HARDY, M.D.

"Human Sensory Response to Acid Mists"—PHILIP DRINKER, SC.D., et al.

"Inhalation Studies of Certain Metal Fumes"—L. LEACH, et al.

Tuesday Evening, April 22

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION Annual Banquet. Cummings Memorial Lecture—LEONARD GREENBURG, M.D.

Wednesday Morning, April 23

JOINT Session A.I.H.A.—I.M.A. Session Arrangers: WARREN A. COOK; ROBERT A. KEHOE, M.D.

Subject: "Toxicology":

Co-Chairman: T. F. HATCH; JAMES H. STERNER, M.D.

"Response of Human Experimental Subjects to Inhaled HF in Concentration Near 3 PPM"—EDWARD J. LARGENT.

"Theoretical Approaches to Treatment of Radioactive and Non-Radioactive Metal Poisons"—JACK SCHUBERT, PH.D.

"Study of Health Problems in Chromate Manufacturing: (A) Environmental Aspects. (B) Clinical Aspects" —Division of Occupational Health, U.S. Public Health Service.

Wednesday Afternoon, April 23

GENERAL Session: Co-Chairmen: THOMAS W. NALE, M.D.; HERBERT T. WALWORTH.

"A Chemical Toxicity Registry"—WILLIAM J. WISSESSER.

"Observations on Cholinesterase Determination in Human Blood by the Michel Method"—L. MONKMAN; C. RACICOT; T. DOHERTY.

"Fatal Exposure to Methylene Chloride Vapor"—SAMUEL MOSKOWITZ, PH.D.; H. SHAPIRO.

"The Relation of Chromium Compounds to Lung Cancer in Animals"—ANNA M. BAETJER, SC.D.

"The Toxicology and Industrial Hygiene Aspect of CBP—55 (1 chloro, 2 bromopropane)"—CHARLES H. HINE, M.D., et al.

"Behavior of Institutional Incinerators when Used to Burn Radioactive Wastes"—ALLEN MACHIS.

(A) "Microdetermination of Chromium with Diphenylcarbazide by Permanganate Oxidation" (B) "Microdetermination of Cadmium with Dithizone"—BERNARD E. SALTZMAN.

Thursday Morning, April 24

CONCURRENT Session: Air Pollution Division—Session Arranger: FREDERICK S. MALLETTE.

Co-Chairmen: HARLOW M. CHAPMAN; LESTER V. CRALLEY, PH.D.

"A Critical Evaluation of the Dustfall Technique for Determining Air Pollution"—BERNARD D. TEBBENS, PH.D.

"Results of a Five-Year Air Pollution Study of the Cincinnati Area"—J. CHOLAK, CH.E.; L. J. SCHAFER; R. HOFFER.

"Preliminary Performance Data on the Spiral Sampler (Film Strip)"—CHARLES D. YAFFE; ANDREW D. HOSEY; JAMES P. SHEEHY; ROBERT S. LLOYD.

"Statistical Correlation between Meteorological Observations and Air Sampling Data—Donora, Pennsylvania, 1949-1951"—HURD C. WILLETT, PH.D.

"The Mathematical Significance of Isokinetic Sampling"—FRANCIS R. HOLDEN, PH.D.

"Air Pollution Studies on a State-Wide Level"—J. S. SHARRAH.

Thursday Afternoon, April 24

CO-CHAIRMEN: JOHN C. SOET; W. C. L. HEMEON.

"The Importance of Sampling Velocity on Particle Size Distribution"—PHILIP DIAMOND; A. J. KAIMALA; RALPH G. SMITH.

"Stack Sampling Studies"—JACK C. RADCLIFFE.

"Natural Radioactivity as an Index of Atmospheric Stability"—RALPH G. SMITH.

"The Use of Exposure Panels in Measuring Air Pollution"—WILLIAM L. WILSON; F. C. MILES.

Thursday Morning, April 24

CONCURRENT Session: Chemical and Analytical Division —Session Arranger: FRANK A. PATTY.

Co-Chairmen: JOHN J. FERRY; DOHRMAN H. BYERS.

"Selected Blood and Urine Changes in Experimental Beryllium Poisoning"—C. T. SPIEGL.

"Improvements in the Determination of Beryllium in the Air and Biological Material"—JACOB CHOLAK, CH.E.; DONALD M. HUBBARD.

"Fluorimetric Determination of Trace Amount of Beryllium"—GEORGE WELFORD; JOHN HARLEY.

"The Ultramicroscope as a Research Tool in Particle Size Analysis"—SIDNEY LASKIN; K. E. LAUTERBACH.

"The Determination of Ozone"—RALPH G. SMITH.

"Polarographic Determination of Thallium in Urine" —GRANT S. WINN, PH.D.

Thursday Afternoon, April 24

CO-CHAIRMEN: JULIUS M. COON, M.D.; JOSEPH F. MELLOR, JR.

"The Relation of the Excretion of Urinary Lead and Coproporphyrin"—JAMES W. HAMMOND.

"Problems in Urinary Coproporphyrin III Analysis"— E. PARKINSON; JACOB CHOLAK, CH.E.

"Are Urinary Coproporphyrins an Index of Lead Absorption?"—KATHLEEN KUMLER; V. J. CASTROP; FRANK A. PATTY.

"Determination of Uranium in Urine Using the Transmission Fluorimeter"—D. EDWARD RUSHING.

"Blood Fluoride Concentrations in Animals Exposed to Hydrogen Fluoride"—F. A. SMITH; D. E. GARDNER; J. DEVOLDRE; HAROLD C. HODGE, PH.D.

"An Electrostatic Isokinetic Dust Sampler (for fast-moving air streams)"—FRANCIS R. HOLDEN, PH.D.

Thursday Morning, April 24

CONCURRENT Session: Engineering Division—Session Arranger: J. C. RADCLIFFE.

Co-Chairman: WILLIAM N. WITHERIDGE; F. A. INGRAM.

"The Design of Vacuum Sweeping and Conveying Systems"—K. J. CAPLAN.

"The Industrial Hygiene Aspects of an Airconditioned Mechanical Shop"—J. W. HAMMOND.

"General Ventilation as a Control of Air Contaminants in a Plastics Plant"—KENNETH E. ROBINSON.

"Design Velocities in Industrial Exhaust Systems"— A. C. STERN.

"Performance of Several Commercial Wet Collectors"— R. DENNIS; M. W. FIRST, SC.D.; L. SILVERMAN, SC.D.

"Efficiency of the Fog Filter for Fume Collection"— D. HUDSON.

Thursday Afternoon, April 24

CO-CHAIRMEN: K. M. MORSE; K. R. DOREMUS.

"Performance Characteristics of Laboratory Hoods" —M. G. KERSHAW.

"Some Statistical Aspects of the Particle Size Problems"—S. LASKIN.

"A Continuous Dust Concentration Recorder"—G. A. SIMON, S. LASKIN.

"Control of a Multiple Source Hazard of Carbon Monoxide"—G. S. REICHENBACH, JR.

"The Control of Cupola Emissions by Electrostatic Precipitator"—J. C. RADCLIFFE; W. F. DELHEY.

"Industrial Ventilation Systems—Design and Application"—(film)—American Air Filter Company.

Thursday Morning, April 24

CONCURRENT Session: Radiation Division—Session Arranger: MERRIL EISENBUD.

Co-Chairmen: K. Z. MORGAN, PH.D.; WILLIAM F. BALE, PH.D.

"The Film Badge in Beta Dosimetry"—EVELYN JETTER; HANSON BLATZ.

"Film Characteristics as Applied to Radiation Monitoring"—JULIAN WEBB, PH.D.

"Status of Neutron Dosimetry"—G. FAILLA, D.SC.

"Cyclotron Radiation Hazards and their Management" —HERBERT MERMAGEN.

"Characteristics of Radiation Survey Instruments."

"Delayed Radiation Effects at Hiroshima and Nagasaki: A Progress Report"—JOHN C. BUGHER, M.D.

Thursday Afternoon, April 24

CO-CHAIRMEN: WILLIAM F. BALE, PH.D.; K. Z. MORGAN, PH.D.

"Meeting Radioactive Waste Disposal Problems in the University and the Hospital"—GEORGE W. MORGAN.

"Engineering Studies of Filter Bed Efficiency for Treatment of Radioactive Wastes"—LEE GEMMELL.

"Contamination Countermeasures"—OSCAR M. BIZZELL.

"The Differentiation Between Radioactive and Non-Radioactive Particles of Collected Dust"—FRANCIS R. HOLDEN, PH.D.

"Self Absorption of Alpha Particles in Filter Paper Counting of Air Samples"—JOHN ALERCIO; JOHN H. HARLEY.

"Status of Scintillation Counting Techniques"—H. KALLMANN, PH.D.

Thursday Morning, April 24

CONCURRENT Session: Toxicology Division—Session Arranger: NORTON NELSON, PH.D.

Co-Chairmen: FRANCIS S. HEYROTH, M.D.; HENRY F. SMYTH, JR.

"The Toxicology of Organic Phosphorous-Containing Insecticides to Mammals"—KENNETH P. DUBOIS, PH.D.; JULIUS M. COON, M.D.

"The Pharmacologic Action and Factors Influencing the Immediate Toxicity of Certain Organic Insecticides" —WILLIAM B. DEICHMANN, PH.D.

"In Vivo Inhibition of Rabbit Serum Cholinesterase by Tricresyl Phosphate Preparations"—E. C. PALMES, PH.D.; NORTON NELSON, PH.D.

"Vapor Toxicity of Ethylene Dibromide Determined on Experimental Animals"—V. K. ROWE; H. C. SPENCER, PH.D.; D. D. MCCOLLISTER; R. L. HOLLINGSWORTH; E. M. ADAMS, PH.D.

"Comparative Inhalation Toxicities of Carbon Tetrachloride, Monochloromonobromomethane, Difluordibromomethane, and Trifluoromonobromomethane to Rats and Mice in the Presence of Gasoline Fires"—CHARLES C. COMSTOCK; FRED W. OBERST, PH.D., by invitation.

"Experimental Studies in Metal Carcinogenesis. II, Uranium Cancers in Rats"—WILHELM C. HUEPER, M.D.

Thursday Afternoon, April 24

CO-CHAIRMEN: HAROLD C. HODGE, PH.D.; DONALD D. IRISH, PH.D.

"Experience with Repeated Intraperitoneal Injections in Chronic Toxicity Screening Tests"—DAVID W. FASSETT, M.D.

"A Method for the Preliminary Assessment of Cumulative Toxicity"—DOROTHY B. HOOD.

"Efficiency of Criteria of Stress in Toxicological Tests" —H. F. SMYTH, JR., PH.D.; R. L. HOLLINGSWORTH.

"The Blood Pressure as an Indicator of Minimal Toxic Effects of Chemicals"—JOHN A. ZAPP, JR., PH.D.

"Physiologic Response to Inhalation of Antimony Trisulfide"—H. BRIEGER, M.D.

"Deposition of Fluoride in and Mobilization of Fluoride from the Tissues of Man"—EDWARD J. LARGENT.

American Industrial Hygiene Association
— News of Local Sections —

Northern California

THE ANNUAL meeting of this section was held at the San Francisco Naval Shipyard on November 20, 1951, with 31 persons present. The following were elected as officers and members of the Executive Committee for 1952: President, EDWARD E. DART, M.D.; President-Elect, OSCAR J. SOBOL.; Secretary-Treasurer, CHRISTINE EINERT, M.D.; Executive Committee: FRANK HOLDEN, Ph.D. (Ex-officio, Past President), CHARLES H. HINE, M.D., A. C. BLACKMAN and BYRON HUBBARD.

The professional status of industrial hygiene laboratories was discussed in relation to the California law defining clinical laboratories and requiring licenses for them.

The members of the Section were escorted through the Biomedical Division of the U.S. Naval Radiological Defense Laboratory. A short film was shown describing the laboratory mission and its present activities of research on prevention and cure of persons affected by radiation sickness. MR. SEIDELMAN officiated as host in the absence of DR. HOLDEN. Interestingly enough the laboratory is not exclusively a Naval laboratory, but derives its support from all of the branches of the Armed Forces and the Atomic Energy Commission. It is, as far as is known, the only laboratory engaged entirely in the defense against atomic weapons.

The meeting of January 15, 1952 was held at the Officers' Club of the Alameda Naval Air Station. Thirty-six members and guests were present. It was voted to send $20.00 to the Victor Nasitar Memorial Fund for the purchase of industrial hygiene books. The following committee for the study of industrial hygiene laboratories was appointed: DR. THOMAS FEICHTMEIR, DR. RODNEY BEARD, WESLEY ROBERTS, and DR. BERNARD TEBBENS.

It was voted to appoint a committee whose function is to obtain publication of suitable material from the Northern California area in the Quarterly or other suitable publications.

DR. IRVING H. WEISENFELD discussed the subject of industrial noise, excluding the occurrence of accident trauma to ears or hearing, based on his experience in the study of hearing as a nose and throat specialist during World War II at the Kaiser Shipyards.

The speaker outlined briefly the literature in relation of hearing to noise, starting with the work of Farbrook 100 years ago on hearing loss in blacksmiths, and continuing to World War I and the work of the Guild at Hopkins on gunfire effect. He pointed out how little could be accomplished until the development of the puretone audiometer between World War I and II made it possible to demonstrate loss and progression of loss. The speaker related his experience at the Kaiser Shipyards II and III, where 100,000 workers were exposed to noise. His study included analysis of exposure levels and in 50% of the work places these levels exceeded 130 decibels. He had the opportunity to examine 100 new employees per month and to follow normal employees at three, six, nine and 12 months and at two years. It was found that interrupted noise causes more loss than a single continuous sound and sharp onset of noise is more traumatic to the ear than gradually increasing noise. Persons in the 20-29 year age range, after one month of exposure to over 100 decibels, developed a notch in the audiometric hearing test curve at the 4000-9000 frequency band. The usual patient's story is, "The noise used to bother me but it doesn't bother me anymore." This is a signal of probable loss of some hearing. The first symptom complained of by persons exposed to damaging noise is "buzzing." After one or two years, the notching at the high frequency level begins to spread and widen similar to the findings in animals. The acuity of hearing of 20% of workers studied, decreased 20 decibels and then stabilized without any further loss; they were considered the noise resistant group. The average hearing loss was usually 60 decibels at the high frequency band.

Treatment is useless and the problem devolves on prevention. Engineering to eliminate noise is of course fundamental. In noise levels over 90 decibels the ears should be protected. Vaseline saturated cotton will reduce the levels 20 decibels. Ear wardens and vaseline will reduce the noise level 30 decibels. A fitted plastic mold will reduce the noise level 35 decibels. Pre-employment examinations of hearing should be mandatory on noisy jobs and follow-up should be within one month for new employees operating in levels of 100 or more decibels of noise. There is need to increase the recognition of this problem among management, insurance carriers, and industrial accident commissions.

Employees having a previous otitis media are more resistant to noise. Hearing tests should be conducted in a room having not over 20 decibels of noise. It is necessary to test persons when they have not been exposed to

noise for one or two days if the maximum hearing capacity is to be obtained. A sweep check test consists of setting an audiometer for a given loss in acuity of 15 or 20 decibels and testing each ear at octaves ranging between 250 and 9,000 or 12,000 cycles.

Chicago Section

AS PER SCHEDULE on the first Wednesday of each month, meetings of the section were held December 6, 1951, January 2 and February 6, 1952.

The speaker for the December 5 meeting was H. B. SNYDER of the Wallace and Tiernan Company who discussed "Industrial Waste Disposal Problems With Emphasis on the Treatment of Cyanides." In addition to the discussion of the industrial waste problem, information was presented on the design and construction of specialized equipment for the treatment of cyanides.

On January 2, WARREN A. COOK of the Zurich-American Insurance Companies discussed "Current Concepts Regarding Maximum Allowable Concentrations." This was a joint meeting with the American Society of Safety Engineers.

The February 5 meeting included a discussion of "Highlights and Trends in Industrial Ventilation and Air Pollution Control" by HARRY G. GRAGG of the American Air Filter Company. MR. GRAGG discussed among other things the types of equipment being used for air pollution control and some of the difficulties being encountered in securing approval of certain types of equipment by different jurisdictions. A 20-minute sound movie entitled "Exhaust Hoods, Their Design and Application" also was shown. This was produced by the University of Michigan Audio-Visual Center in collaboration with the Michigan Department of Health and American Air Filter Company.

Upper and Western New York

ON SATURDAY, December 1, 1951, a symposium was held on pulmonary function and industrial hygiene at the University of Rochester School of Medicine and Dentistry. The program was as follows: "Pneumotachography in the Study of Respiratory Dysfunction" by DR. PAUL MORROW, University of Rochester Atomic Energy Project; "Toxicity of Organic Phosphates Useful as Insecticides" by DR. WILLIAM DEICHMANN, Albany Medical College. "Cancer of the Lung in Animals Exposed Experimentally to Beryllium Dust" by DR. ARTHUR VORWALD, Trudeau Foundation; "Pulmonary and Metabolic Disturbances in Persons Exposed Industrially to Beryllium" by DR. JOE HOWLAND, University of Rochester Atomic Energy Project.

Greater St. Louis Section

THE MEETING on December 4, 1951, with some 30 members in attendance, was addressed by V. J. CASTROP, Assistant Head of the Industrial Hygiene Department, General Motors Corporation, who spoke on "Industrial Hygiene in General Motors." Announcement was made that the next meeting of the group would be a joint one with the Industrial Nurses Association of St. Louis and the St. Louis Safety Council.

Ohio Valley Section

ON DECEMBER 5, 1951, the Ohio Valley Section held a symposium on "What is *My* Concept of Industrial Hygiene," to which industrial nurses, safety engineers and plant personnel were invited. About 75 persons attended.

The following participated in the panel discussion: ELMER BARKER, Safety Engineer, American Rolling Mills Company, Middletown, Ohio; DR. L. W. SPOLYAR, Director of Industrial Hygiene, Indiana State Board of Health, Indianapolis; W. B. HARRIS, Chief, Industrial Hygiene Branch, New York Operations Atomic Energy Commission, New York; MISS WINIFRED DEVLIN, Senior Nurse Officer (R) Division of Occupational Health, U.S. Public Health Service, Washington, D.C.; DR. H. W. LAWRENCE, Medical Director, Proctor and Gamble Company, Cincinnati; DR. R. A. KEHOE, Director, Department of Preventive Medicine and Industrial Health, College of Medicine, University of Cincinnati.

On Wednesday, January 9, the Ohio Valley Section held its annual meeting. DR. SEWARD E. MILLER, Chief, Division of Occupational Health, U.S. Public Health Service, Washington, spoke on "Past and Future Growth of U.S. Public Health Service."

The following election results were announced: President, CHARLES D. YAFFE, Chief, Engineering Section Division of Occupational Health, U.S. Public Health Service; President-Elect, EDWARD J. LARGENT, Research Associate in Preventive Medicine and Industrial Health, Kettering Laboratory, University of Cincinnati; Secretary-Treasurer, ANDREW D. HOSEY, Sanitary Engineering, Division of Occupational Health, U.S. Public Health Service.

DR. JOHN J. PHAIR, Professor of Preventive Medicine, College of Medicine, University of Cincinnati was elected to the Board of Directors.

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